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ENERGY EFFICIENT STOVES IN EAST AFRICA:
AN ASSESSMENT OF THE KENYA CERAMIC JIKO (STOVE) PROGRAM

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LIST OF TERMS AND ABBREVIATIONS

A.I.D.	(U.S.) Agency for International Development
ATI	Appropriate Technology International
CWG	Claystoves Working Group
fundi	Artisan
GTZ	Deutsche Gesellschaft fur Technische Zusammenarbeit (German agency for technology cooperation-aid)
Harambee	Self-help--literally "pulling together"
ITDG	Intermediate Technology Development Group
jiko	stove in Kiswahili
KCJ	Kenya Ceramic Jiko
KENGO	Kenya Energy and Environmental Organizations
KU-ATC	Kenyatta University-Alternative Technology Centre
LPG	Liquified Petroleum Gas
MOE	Ministry of Energy (Kenya)
NORAD	Norwegian Agency for International Development
ODA	Overseas Development Administration, U.K.
REDSO	A.I.D. Regional Economic Development Support Office
SREP II	Phase II of the Sudan Renewable Energy Project
TMS	Traditional Metal Stove
UNCNRSE	United Nations Conference on New and Renewable Sources of Energy
UNICEF	United Nations Children's Fund, N.Y.

CURRENCY CONVERSION

$1.00 = Ksh. 18.0 (August 1988 rate)

EXECUTIVE SUMMARY

BACKGROUND

The purpose of this report is to assess the development and introduction of an energy conserving charcoal stove for household use in Kenya. This assessment is intended to: a) examine the status of the Kenya program and to offer recommendations to enhance the program, b) utilize the Kenya program as a model for the formulation of guidelines for similar household fuel conservation programs, particularly in East and Southern Africa, and c) provide a basis for application of lessons learned to current stove conservation activities such as those of the Agency for International Development in the Sudan and the World Bank in the Sudan and elsewhere in Africa.

In Kenya, wood energy accounts for over 70% of total energy consumption, with the vast majority being used in rural and urban households. Charcoal production in Kenya accounts for about 27% of all wood utilization, with urban charcoal use comprising roughly 60% of this total, with the balance being used in rural areas. Utilization of wood resources for energy purposes as well as destruction of biomass from agricultural clearing and other factors, is leading to a significant depletion of biomass stocks and significant negative environmental impacts.

An improved stove program was initiated in Kenya in the early 1980s in response to biomass supply and environmental concerns. The program resulted in the development and dissemination of a more efficient charcoal stove, the Kenya Ceramic Jiko (stove) or KCJ. The experience of the KCJ is particularly important because it is one of the few such programs that has resulted in the introduction of a large number of improved stoves. The KCJ program was a combined effort of many groups, but the Kenya Renewable Energy Development Project (KREDP) was the major catalyst. The KREDP was jointly sponsored by the Agency for International Development (A.I.D.) and Government of Kenya. The project primarily addressed urban charcoal fuel conservation and did not address either rural fuelwood use or broader household fuel questions.

KENYA STOVE PROGRAM FINDINGS

The Kenya stove program can be judged generally successful because:

1. users have found that the KCJ reduces charcoal expenses considerably (by 15-40%), are satisfied with performance and durability, and are buying stoves through normal commercial channels;[1]

[1] Savings of 20%, a conservative minimum level, would produce savings of Ksh. 350/- per year which, for a low income family, would equal about 1/2 of one month's income ($1.00 = Ksh. 18/-).

2. producers find the KCJ profitable to manufacture, and retailers and informal sector assemblers of the KCJ have become heavily involved in commercial sales, with current sales levels estimated at 125,000-140,000 per year;

3. competition has significantly lowered initially high prices in Nairobi the major market;

4. government has appeared satisfied with the beneficial employment and income enhancement impacts of the project; and

5. A.I.D. has satisfied its objectives to conserve energy and create a self-sustaining production capability.

Project Experience. Early in the project, the KREDP developed and applied a comprehensive set of stove selection criteria and adopted a private sector-oriented approach to production. In retrospect, both decisions were important to the project's success. The hiring of a local Kenyan stove adviser, careful laboratory tests on efficiency, a field trip to Thailand to study first-hand the manufacture of a particularly promising design, and a field test to gather consumer reactions and modify the stove, all contributed significantly to early stove development. These careful development steps were essential to the successful adaptation of the KCJ to local conditions.

The KCJ is manufactured from two primary components: an outer metal cladding and a ceramic liner inserted with insulation. The manufacture of metal claddings is undertaken primarily by informal sector metal workers. For ceramic liner production, three general systems of manufacture have emerged since the project's inception: mechanized, semi-mechanized, and artisanal. The manufacture of quality ceramic inserts has been much more successful in the semi-mechanized and the mechanized production operations. The greatest commercial success has been associated with producers exhibiting a combination of entrepreneurial skill, possessing adequate capital, and a willingness to devote management time to production and marketing, and prior experience and an ability to organize production by metal working artisans.

Implementation Lessons Learned. Implementation within commercial manufacturing and marketing systems was the key to the success of KCJ technology dissemination. Certain common lessons from the Kenya experience stand out as critical to success. These result in the following findings: a) assistance should be directed toward private sector firms or individuals, for whom the assistance will have the most leverage in achieving results; b) technology and other inputs provided should be as similar to those of the present enterprise as possible (e.g., in tools, materials, cost, etc.) and must also be adapted to the local environment (not simply "imported"); c) an assessment of needs, followed by field tests, is required before appropriate stove or other improvement can be designed or adapted for the market; and d) existing and proven institutions and production systems and markets should be built upon, rather than trying to create new institutions or systems, or trying to impose substantially different functions on existing institutions.

Outstanding Issues. A number of gaps and constraints were identified in this report. Information by which to review and improve the KCJ business is not readily available and such important areas as market penetration, stove durability, and ownership patterns are poorly understood. Government budgetary support for such stove activities has also been decreased substantially in recent years. Furthermore, the availability of the KCJ in the marketplace remains inadequate for the potential market both in Nairobi and elsewhere, and prices are too high outside Nairobi for many potential consumers. Dissemination of stove production technology is impeded by the lack of adequate, generally available information on the technology for replication purposes. Consumer awareness needs to be increased on how to use the stove and on its prospective benefits.

Suggested Actions for the Kenya Stove Program. In order to remedy the gaps and constraints found in the KCJ activities and enable this program to realize its full potential, a number of actions are needed. These include the following:

1. Government support at the national and provincial/district level to create the policy environment for the dissemination of the KCJ via a broad promotional effort and high level backing.

2. Systematic evaluation and monitoring to provide better understanding of sales patterns, stove prices in major markets, stove penetration, stove quality, charcoal and paraffin (kerosene) prices, charcoal savings, and to identify and resolve related problems.

3. Increased public information on stove selection and use to both stimulate demand and assist consumers in proper utilization.

4. Expansion of technical assistance for new producers to make help more readily available in areas such as clay selection and preparation, production technology, and establishment of minimum quality guidelines. Support should be considered for institutional/commercial stoves as well.

5. Provision of credit to producers for the expansion of production, particularly outside Nairobi. A.I.D.'s Rural Enterprise Program or the Ministry of Energy's (MOE) "Energy Development Fund" could be adapted for this purpose.

GENERIC GUIDELINES FOR OTHER PROGRAMS

An improved stove program is only one of a number of options for responding to a household energy problem. Other alternatives include: modification of government policies such as those regarding relative fuel prices, the production of new biomass supply and the substitution of alternative fuels, and/or improving the efficiency of charcoal conversion. An improved stove activity, therefore, should be considered as only a part of an overall household fuel program.

The following summarizes the major components which should be included in a comprehensive stove program:

1. Assessment of the biomass resource base, charcoal and fuelwood supply systems, household utilization patterns and markets, and the availability of substitute fuels in order to form a baseline prior to undertaking prototype development and/or dissemination.

2. Prototype development and testing in the laboratory and in field tests to identify candidates and test efficiency, durability, cost, feasibility of production, consumer acceptability, and materials.

3. Development of a dissemination strategy to identify and evaluate prospective private producers, and to establish a means for credit and technical assistance delivery.

4. Production systems and equipment development for the manufacture of improved stoves. For ceramic stoves, the production program must include the development of criteria for clay selection and mixture, molding and preparation technology, and kiln construction and operation.

5. Quality assurance program or strategy, particularly when relying on commercial systems as the primary mechanism for the production and dissemination of stoves. It may include: a) consumer information and education on how to select stoves for quality and on proper use of stoves, b) training of producers and artisans in production techniques and materials, c) monitoring and testing by appropriate Government or other groups, and d) standards development, monitoring and possibly enforcement, although certification is a more positive option.

6. Training activities for creating the technical and management capability to carryout the program, and for directly expanding the number of stove manufacturers capable of producing improved stoves.

7. Marketing and promotion assistance to spread awareness of improved stove availability and benefits and to augment producers' efforts.

8. Monitoring and evaluation of stove and project performance, improved stove penetration and associated issues, and provision of coordination mechanisms between programs.

9. Project design, planning and budgeting to ensure the effective execution of all the functions, including: a) adaptation of the project to availability of local skills, materials and equipment, and socio-economic characteristics; b) learning from other local or regional efforts of a similar nature; and c) a realistic assessment of local institutional capability, administrative and recruitment issues, training requirements, and staff attrition.

In the process of developing generic guidelines to assist programs in the region, it became clear that there is substantial unmet need for technical assistance in most countries. Furthermore, project specific technical assistance which relies heavily on expertise from outside the region is more likely to produce inappropriate advice and results. At the same time, there is great potential for more regional cooperation and technical interchange to facilitate and supplement country programs. Unfortunately, the appropriate institutions within which to locate and expand this capability, and thereafter to disseminate technical and program assistance, are not yet clear. *It is strongly recommended that there be further definition of this regional technical assistance approach, and that support be provided for establishment of an appropriate regional "facility" to assist in energy conserving stove development and other household energy programs.*

SUDAN RENEWABLE ENERGY PROJECT II

In this report we have briefly reviewed the Sudan household energy situation and the improved stove activity of A.I.D. in the Sudan and attempted to apply some of the lessons learned in Kenya to this situation. The Sudan Renewable Energy Project (SREP), sponsored by A.I.D. and the Government of the Sudan, began in 1982 and focused on, among other things, the development of energy conserving stoves. Phase II (SREP II) of the project contains a charcoal conservation component focusing on the introduction of improved charcoal stoves. While the Kenya experience has substantial relevance for the Sudan, differences between Kenya and the Sudan will require many local adaptations. The Sudan project is the only A.I.D. improved charcoal stove promotion activity currently underway in East Africa and has had a close historical relationship to the Kenya Ceramic Jiko and its production technology. The KCJ was introduced into the Sudan several years ago, under CARE guidance with A.I.D. support, and is currently being produced by one firm.

Based on a brief review of the Sudan situation and a consideration of the lessons learned from the Kenya program review and Generic Program Guidelines above, the following specific suggestions are offered for the Sudan program:

1. Large scale production or consumer promotion efforts should follow further evaluation of the stove market and production systems, and laboratory and pilot field tests for new stoves should be conducted to ensure confidence in the appropriateness of stove(s) to be introduced, in terms of cost, durability, ease of production, and widespread acceptability.

2. Technology, materials and dissemination methods should be closely tailored to be compatible with the traditional local stove production and dissemination system.

3. Given the low cost of existing stoves (roughly Ls 10-12) versus improved versions and the difficultly of converting the traditional production system into a part of the improved ceramic stoves systems, further effort should be devoted to improvements in the traditional stove, as well as an evaluation of alternative all-scrap metal stoves.

4. A low-cost all-ceramic stove appears to be another appropriate alternative for the Sudan. Such a stove will require further design, evaluation, and field test efforts before it can be judged ready for dissemination. Additional support should be obtained from the local and international sources to simplify and ensure high quality in this product.

5. Support should be provided to assist local private businesses with manufacturing, marketing, and credit needs in order to promote commercial production of improved stoves. Selection of firms for production support should be carefully carried out in light of the implementation lessons in this report. (Sections VII and VIII)

6. The project should financially and technically support efforts in monitoring and evaluating charcoal consumption and fuel switching before and after improved stove purchase, as well as efforts in surveying and monitoring traditional and improved stove production.

7. The project should further evaluate fuel substitution issues (e.g. relative fuel pricing, supply, and distribution) and alternative fuel options and monitor relative fuel prices and availability over time.

8. Assistance should be provided to the Sudan Energy Research Council and the National Cookstoves Network (administered by the National Energy Administration), to establish uniform field testing and monitoring criteria for improved stove activities in the Sudan.

9. Standardized laboratory and kitchen standards should be developed and adopted through the National Cookstoves Network (NCN).

Given the limited time and budget for the SREP II project to meet its objectives, the project will need to be selective in the choice of activities it undertakes. The scope of activities suggested above, while comprehensive and appropriate, may not be feasible. However, given the opportunity to both set-the-stage for the planned World Bank "Wood Energy Conservation Project," and the need to establish a sound basis for future work, the components above appear to be those meriting highest priority consideration.

I. INTRODUCTION

Wood and other forms of biomass remain the primary sources of energy for the majority of households in Africa. In fact, these sources dominate the energy systems in developing countries in general. The belief that deforestation must necessarily lead to a fuel supply "crisis," coupled with early findings that the efficiency of traditional open fires was very low, led to many stove and other conservation projects worldwide beginning in the mid-1970s.

By the mid-1980s there was a general disillusionment with the results of stove programs, as it was clear that no large-scale diffusion had occurred, and that stove quality and usage levels were poor. In addition, the linkage between rural wood use for energy and deforestation has now been seriously questioned, as agricultural land clearing, commercial timber cutting, and charcoal production for urban consumption appear to be more significant factors.

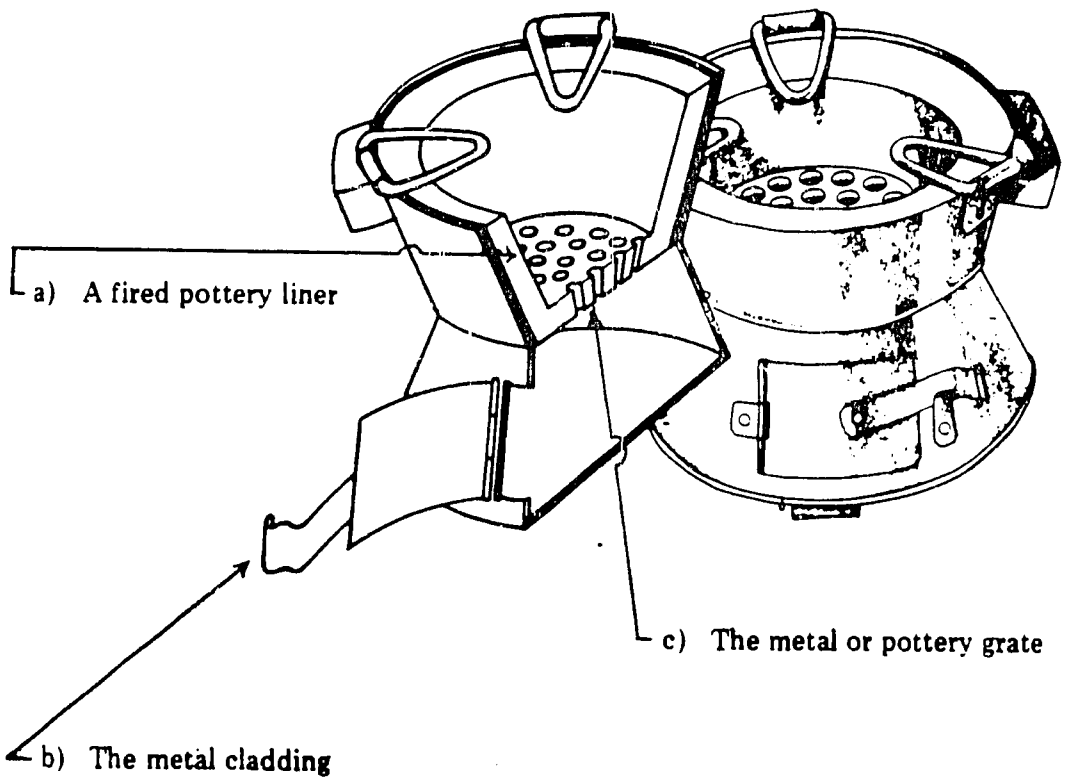
In 1981-82 the depletion of Kenya's biomass resources was becoming an important national environmental and social issue. The Kenya Ceramic Jiko (Stove) for charcoal was developed and disseminated as part of a project beginning in the early 1980s to respond to the perceived problem of deforestation. The Kenya Ceramic Jiko is generally considered one of the more successful improved stove programs, since it has been substantially introduced into the commercial market and has achieved a self-sustaining status. While this program has been reviewed a number of times in the past, its status has not been thoroughly evaluated, nor have the lessons from this experience been adequately drawn-out for replication.

Purpose: The purpose of this report is to assess the development and introduction of an energy conserving charcoal stove for household use in Kenya. This assessment is intended to: a) examine the status of the Kenya program and to offer recommendations to enhance the program, b) utilize the Kenya program as a model for the formulation of guidelines for similar household fuel conservation programs, particularly in East and Southern Africa, and c) provide a basis for application of lessons learned to current stove conservation activities such as those of the Agency for International Development in the Sudan and the World Bank in the Sudan and elsewhere in Africa.

Report Structure: This report consists of three major parts. First, Sections II and III provide on overview of household energy issues and policy options and describe the Kenya energy situation as background. Second, Sections IV through VII describe and analyze the Kenya Ceramic Jiko experience, analyzing in detail estimated charcoal savings, production technology, and implementation lessons. Finally, Sections VIII and IX present guidelines for future improved stove programs and apply the lessons learned from the Kenya experience to the situation in the Sudan to assist the current U.S.A.I.D. Sudan Renewable Energy Project and planned wood energy conservation efforts of the World Bank.

KENYA CERAMIC JIKO (STOVE)

Main Components



II. HOUSEHOLD ENERGY ISSUES AND OPTIONS IN AFRICA

THE ROLE OF BIOMASS FUELS

Forest and savannah woodlands in Africa provide the majority of household energy for cooking, household enterprise, and other domestic uses such as space and water heating. In Africa, over 90% of the population uses fuelwood for cooking at the equivalent of about three to four metric tonnes of wood equivalent per family per year. Utilization for energy purposes as well as destruction of wood and other biomass due to agricultural clearing and a variety of other factors has led to significant depletion of woody biomass stocks in many African countries. It has been estimated that the area of forested woodland in Africa has been halved since 1900 and that the pace of deforestation and land degradation is actually increasing.[1]

The rate of depletion of Africa's biomass resources is the combined effect of many factors, the most significant of which are high levels of population growth and the associated need for new agricultural clearing, dependence by households on woodfuels for cooking, excessive numbers of livestock, and commercial logging. The relative contribution of these factors to the problem, however, has not been adequately documented and is poorly understood.

IS THERE A WOOD ENERGY CRISIS?

Various arguments can be offered as to why we need to do something about the wood energy situation in Africa. Clearly in some countries the lack of control over the cutting of natural forests is cause for alarm and may be causing irreversible changes in the ecology of rural areas, principally in the carrying capacity and fertility of the soil.[2] In some countries, greater woodfuel scarcity in rural areas significantly increases the labor required of women and children for fuel gathering. The degree of resource degradation and population pressure, however, varies greatly at the regional and sub-regional levels, requiring that household energy policy and programs be country-specific.[3]

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[1] Dennis Anderson and Robert Fishwick, Fuelwood Consumption and Deforestation in African Countries (World Bank, 1984).

[2] Dennis Anderson, The Economics of Afforestation: A Case Study in Africa, World Bank Occasional Paper #1 (1987).

[3] David J. Jhirad and Gunter Schramm, Energy Strategy in Sub-Saharan Africa (Office of Energy--Agency for International Development and World Bank, 1984), p. 12.

As in other countries, in Kenya it is generally accepted that there is a physical divergence or "gap" between biomass consumption and accessible supplies from regeneration (otherwise referred to as "sustainable supplies"). It has frequently been argued that the woodfuel supply-demand "gap" implies a crisis. However, recently, this theory of a so-called "gap" between sustainable woodfuel consumption and supply has been called into question as an inadequate "snapshot" description of what is part of a natural process.[4] Rather than a gap-induced crisis arising, mounting evidence indicates that economic forces cause this imbalance to be bridged by both the substitution of alternative fuels and the husbanding of scarcer resources. Higher real prices (in monetary or human-effort terms) also induce the production of additional supply, as well as encourage conservation.

Because the "gap" concept ignores the effects of real price changes and fuel substitution, the concept is overly simplistic and can mislead policy-makers and others into planning inappropriate actions in response. However, it is similarly inappropriate for better understanding of the gap issue to stimulate policy complacency given the seriousness of deforestation in Africa.[5] It has been observed that as wood for fuel becomes more scarce, for example, there is a shift to lower and lower quality biomass fuel such as biomass residues. This is sometimes referred to as the "paradox of the pyramid," whereby a regression in fuel use occurs from top quality firewood to lower quality firewood and then to twigs and bushes, and then to general crop residues as woodfuel supply declines further.[6] This progression down the pyramid proceeds not only from the increasing scarcity of biomass fuels in rural areas, but also from inadequate household income and the failure of governments to supply more modern fuels at affordable prices. In contrast, the progression observed in the western nations has not been from wood to crop residues. On the contrary, as wood fuel use has declined a shift has occurred to both more convenient and higher quality fuels as a conscious economic and social decision.

To doom the developing countries to proceed down the biomass pyramid is not a sound economic or social policy prescription. The relative ineffectiveness of many of the supply-side wood energy programs, the social costs of site-specific shortages, and inability of the poor to pay higher prices, taken together with the observed high rates of deforestation argue for more concerted and effective action by Governments and donors.

OPTIONS FOR DEALING WITH HOUSEHOLD FUEL PROBLEMS

The policy options for dealing with the higher cost and/or increasing scarcity of traditional household fuels in Sub-Saharan Africa fall into three categories: first, conservation through changes in cooking technology and methods; second, increased supplies through investment in forestry or agro-forestry and, o a much lesser extent,

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[4] Gerald Foley, Discussion Paper on Demand Management, World Bank Eastern and Southern Africa Household Energy Planning Seminar, (Harare, Zimbabwe: February 1988), p. 5.

[5] Gerald Foley, "Exaggerating the Sahelian Woodfuel Problem?" Ambio, Vol. 16, No. 6 (1987).

[6] Foley, Discussion Paper..., p. 6.

biomass residues utilization; and third, substitution, principally of modern fuels such as kerosene, LPG and electricity, for traditional charcoal and fuelwood used in rural and urban areas.

In the past, there has been a tendency to emphasize supply solutions rather than to address these three aspects in an integrated fashion. In the household fuel area this has tended to mean that the bulk of attention has gone to wood supply via conventional forestry initiatives. In the modern commercial energy sector, that is, in organizations dealing with petroleum and electricity matters, household energy issues have not been a high priority. This is understandable given the magnitude of expenditures for petroleum imports (predominantly for transport and industry) and the huge capital cost of electricity supply. However, in the African context 70%-90% of national energy budgets are derived from biomass and 80-90% of the population are without electric power, indicating a need for a fundamental reassessment of energy sector priorities.[7]

SUPPLY OPTIONS

It is now widely accepted that the conventional forestry-based wood supply approach will be both too costly and insufficiently effective to greatly increase biomass supplies in Africa. In a World Bank Energy Policy Paper, for example, it was estimated that even if the demand for wood were reduced by 20-30% through conservation and substitution, a 15-fold increase in current planting rates in forestry programs would be required in African countries to be able to restore the balance between supply and demand by the year 2000.[8] Some recent evidence indicates that the cover in densely populated areas, such as Rwanda and Western Kenya, may actually be increasing. However, this tree cover which may be trees for commercial purposes, such as for poles or fruit, does not necessarily translate into wood for energy purposes. Nonetheless, given the growing depletion of biomass supplies in Africa due to agricultural clearing, energy uses, and commercial wood utilization, it is unlikely that stabilizing biomass supplies at current levels is an achievable goal.

Particularly important to new woodfuel supply initiatives is the creation of an appropriate pricing and tax structure which will encourage private production, give appropriate signals concerning the utilization of different fuels, and provide revenues sufficient to finance needed supply programs. Agro-forestry (on-farm forestry) approaches within the private sector also appear to promise more economical and effective means to achieve higher rates of biomass planting. The agro-forestry approach appears to have substantial advantages over traditional forestry practices including: the ability to achieve higher planting rates stimulated by commercial incentives, reduced need for public wood supply expenditure, enhanced soil fertility and fodder production for livestock, reduced demand for land, and more effective use of small areas of farmland.[9]

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[7] Jhirad and Schramm, Energy Strategy...

[8] Anderson and Fishwick, Fuelwood Consumption and Deforestation...

[9] Anderson, The Economics..., pp. 20-22.

Another option, given the cost and difficulty of providing new biomass supplies, is to focus supply programs only on cities, urban areas and specific rural areas with serious current or potential problems.[10] The development of commercial peri-urban plantations to provide fuel for specific urban areas and industry may be one response to geographically specific needs. However, in many instances, market prices of biomass fuels are insufficient to support commercial viability of peri-urban plantations, and government subsidies would have to be so great to such plantations that only a small part of the wood deficit problem would be solved.[11] Finally, in some countries biomass residues within economic transport distance of urban or commercial markets offer significant scope for near-term supply (notably in Malawi and Madagascar).

FUEL SUBSTITUTION

In addition to producing new biomass supplies, substitution of alternative fuels as a strategy may offer benefits complementary to new supply and conservation. Substitution is influenced by a number of factors including relative fuel prices, income growth, urbanization, preferences in terms of fuel quality and convenience, reliability and overall levels of fuel supply, and energy conversion equipment cost.

Fuel substitution as a household energy supply strategy in Africa is faced with a number of serious constraints. Most importantly, there is considerable dispute concerning whether or not scarce foreign exchange should be allocated for the substitution of modern fuels (e.g., kerosene, LPG, and electricity) for traditional fuels. Such substitution would mean shifting development priorities and require significant changes in relative price levels to stimulate fuel switching. One study sponsored by the World Bank indicated that substitution from charcoal to kerosene would raise total petroleum demand by significant but varying amounts of up to 38% in the African countries reviewed. Given the scarcity of foreign exchange in African countries, any significant increase in petroleum import costs would be both difficult to justify and finance.[12]

Rural fuel substitution is a particularly complex issue because the cost of distributing commercial fuels is high and the distribution systems are often inefficient or underdeveloped in Africa. The frequent result of distribution inefficiency is scarcity and unreliability of supply of rural commercial fuels. Poor distribution systems are subject to improvement, but these will require changes in politically sensitive pricing and fuel allocation policies, and possibly changes in institutional structure. Increasing kerosene supply, specifically for household purposes, is also made more difficult and costly as kerosene may instead be used as an additive to diesel transport or diesel engine fuels.

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[10] Jhirad and Schramm, Energy Strategy..., p. 39.

[11] David French, "Confronting an Unsolvable Problem: Deforestation in Malawi," World Development, Vol. 14, No. 4 (1986).

[12] Gerald Leach, Interfuel Substitution, paper presented at the Household Energy Planning Seminar for Eastern and Southern Africa (February 1-5, 1988), p. 17. (These results apparently exclude energy using device costs which would add substantially to estimates.)

Notwithstanding the constraints to fuel substitution described above, it is evident that major transitions to modern fuels have occurred in developed countries, and similar trends are evident at least in urban areas in many developing countries. *Unfortunately, there is an inadequate understanding of the feasibility and desirability of promoting modern fuel substitution in most developing countries and, therefore, there is usually no sound basis for implementing such policies. Understanding these trends, and assessing the potential options for affecting them, should be a priority for future household fuel research.*

DEMAND MANAGEMENT

Demand management (or conservation) many refer either to improvement in the efficiency of fuels used or to increased intermediate conversion efficiency, e.g., production of charcoal from wood. A range of policy measures and technical changes are available which contribute to conservation of energy use by households. These can be aggregated into four basic categories:

1. Public policy measures--e.g., pricing policy, fuel supply control and regulation, and public information and propaganda.

2. Intermediate fuel conversion efficiency improvements-- e.g., wood conversion in kilns to charcoal or fuel conversion to electricity.

3. End-use efficiency improvements--household stoves or other household fuel using equipment, e.g., for space and water heating, lighting, food preservation, etc., and shifts in cooking methods and/or cooking vessels (e.g., from clay to aluminum pots).

4. Shifts in the basic patterns of demand--e.g., shifts to processed rather than traditional foods and to purchasing prepared meals as opposed to household cooking.[13]

What Role Might Improved Stoves Play in Conservation? Past household fuel conservation projects have dealt primarily with improving end use efficiency. The conventional wisdom had been that a reduction of up to 50% in fuelwood and charcoal use was achievable. However, experience has shown that for many technical, social, and economic reasons, such large savings are very difficult to achieve in actual practice. Furthermore, low public adoption rates and the lack of self-sustainability have led to very few actually successful energy conserving stove programs.

A recent review sponsored by the Food and Agricultural Organization (FAO) and the Foundation for Wood Stove Dissemination (FWD) was undertaken to help determine the impact and effectiveness of selected past stove programs. The study tended to confirm the view that rural stove programs do not directly contribute to reduction in deforestation.

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[13] Other important social changes affecting energy requirements, but not normally considered in household energy policy, include population control, income redistribution, and income enhancement.

However, it was concluded that urban programs dealing with commercial fuels and aimed at large scale dissemination of more efficient stoves may have a significant conservation impact. Similarly, successful stove programs were shown to have many other economic and social benefits.[14]

Given this potential for stove programs to actually result in conservation of biomass resources, and to produce substantial socio-economic benefits, it is extremely important to learn how to more effectively implement such programs. The remainder of this report assesses the experience in developing the Kenya Ceramic Jiko, with the intention of helping to improve the success rate of future projects of this type.

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[14] Stephen Joseph, An Appraisal of the Impact of Improved Wood Stove Programmes: Synthesis of Experience (Sydney, Australia: Biomass Energy Systems Technology: 1987), p. 32.

III. ENERGY SUPPLY AND DEMAND IN KENYA

An understanding of the energy supply and demand situation in Kenya is important to provide a context for the improved stove program assessed in this report. Such information helps one understand the justification for introducing an improved stove, for example, whether or not there have been real price changes, and the degree of biomass fuel use and degree of scarcity--all of which affect the viability of an improved stove program.

In 1981-82 the depletion of Kenya's biomass resources was becoming an important national issue. A major research project which finished in 1982 documented the rapid decline in the biomass fuel supply and proposed greater Government intervention in both supply and demand management.[1] Also stimulating the Government to take action in energy conservation was the increased burden from oil import costs with Kenya spending some 60% of non-oil export earnings[2] annually (about Kenya £230 million) to import oil, versus only 0.8% in 1973.

In the early 1980s, the Kenya Government initiated a number of new or expanded programs in its energy, forestry, agriculture, and district development agencies, among others, in an attempt to augment biomass supply and improve both biomass and petroleum utilization efficiency. The Kenya Renewable Energy Development Project (KREDP) was initiated in 1981 as part of an Agency for International Development (A.I.D.) and Government of Kenya effort to augment biomass energy supply, to increase efficiency in biomass utilization, and to conserve imported oil. One important component of the project was the introduction of improved stoves primarily as a biomass conservation measure.

WOOD ENERGY DEMAND AND SUPPLY

Wood energy is estimated to supply about 70% of total energy used in Kenya. The quantities of woodfuel required are very large, estimated at about 22.9 million tonnes in 1985. Urban requirements for wood-based energy consist primarily of domestic demand for charcoal which required about 3.0 million tonnes of wood input in 1985 and was roughly 90% of total urban wood energy demand. Due to a continuation of extremely high overall population growth rates (4% per year) and even faster urban growth, urban charcoal demand is projected to grow to over 7.0% per year over the next 10-15 year period. After taking into consideration conversion losses in the production of charcoal from wood, total urban and rural charcoal consumption is shown to account for about 27% of all wood

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[1] Phil O'Keefe, Paul Raskin, and Steve Bernow, Energy and Development in Kenya (Stockholm: The Beijer Institute, 1984).

[2] Kenya obtains substantial revenues from the reexport of oil products which are excluded for this comparison.

required for energy and non-energy uses (see Table III-1). While it is recognized that there is a tendency for the urban population to gradually shift more to modern fuels in urban areas due to availability and income growths, this pattern is poorly understood and, therefore, not explicitly included in the forecasts in Table III-1. Rural household demand for wood is the single largest wood energy requirement estimated at about 12.6 million tonnes in 1985, but growing at a much slower pace than charcoal demand, about 2.5% per year, roughly the same rate as population growth.[3]

TABLE III-1
FORECAST OF WOOD AND CHARCOAL DEMAND IN KENYA
(1985-2000)
(Units - Million Gigajoules)*

SECTOR	1985 WOODFUEL	1985 CHARCOAL	1985 TOTAL	1990 WOODFUEL	1990 CHARCOAL	1990 TOTAL	2000 WOODFUEL	2000 CHARCOAL	2000 TOTAL
URBAN HOUSEHOLDS	4.4	11.7	16.1	6.0	16.6	22.6	13.9	34.4	48.2
RURAL HOUSEHOLDS	194.9	7.8	202.7	220.2	8.6	228.8	283.8	10.7	294.5
SUBTOTALS HOUSEHOLDS	199.3	19.5	218.8	226.2	25.1	251.3	297.7	45.0	342.7
INDUSTRY									
LARGE	22.8		22.8	29.8		29.8	50.8		50.[illegible]
RURAL	35.0	2.3	37.3	40.3	2.5	42.8	50.7	2.8	53.[illegible]
URBAN	0.6	1.3	1.9	0.8	1.9	2.7	1.5	2.9	4.[illegible]
COMMERCIAL	1.9	0.456	2.4	2.3	0.520	2.8	3.2	0.620	3.[illegible]
NON-ENERGY	8.2		8.2	10.8		10.8	18.4		18.[illegible]
SUBTOTAL OTHERS	68.5	4.1	72.6	84.0	4.9	88.9	124.5	6.3	130.[illegible]
TOTAL WOOD & CHARCOAL END-USE DEMAND (Million Gigajoules)	267.8	23.6	291.4	310.2	30.1	340.2	422.2	51.3	473.[illegible]
WOOD REQUIREMENT INCLUDING CHARCOAL CONVERSION LOSSES	1985 WOODFUEL	CHARCOAL	TOTAL	WOOD REQUIREMENT 1990 WOODFUEL	CHARCOAL	TOTAL	2000 WOODFUEL	CHARCOAL	TOTAL
MILLION TONNE	16.7	6.1	22.9	19.4	7.5	26.9	26.4	12.2	38[illegible]
PER CENT	73%	27%	100%	72%	28%	100%	68%	32%	1[illegible]

SOURCE: Author's estimate. Oak Ridge Associated Universities, March 24, 1988

(Charcoal figures are adjusted for error in Beijer Institute average national use, i.e., the proper figure of 473kg/average household used here in 1985 base case, rather than the figure of 673kg/housenol which properly applies only to urban families using charcoal.

* Million Gigajoules equals 23,900 tonnes of oil equivalent.

[3] Central Bureau of Statistics, Population Projections for Kenya-1980-2000 (Republic of Kenya, 1983).

Contrary to the conventional wisdom that the bulk of charcoal demand is from major urban centers, estimated demand in Kenya's four largest cities is only 35% of the total, with 25% occurring in other urban areas and about 39% in areas classed as rural.[4] *Use of charcoal outside of major urban centers is therefore more significant for future planning than normally assumed.* Another important factor influencing charcoal demand will be future changes in the distribution of urban population. Urban population concentration is projected to shift increasingly from Kenya's two major urban areas of Nairobi and Mombasa to smaller centers. This distribution has an important impact on the economically available supply of wood for charcoal as more dispersed and smaller urban population centers are closer to sources of rural wood supply.

The projections in Table III-1 assume modest introduction of improved stoves, improvements in efficiency of charcoal use, some improvement in charcoal conversion efficiency, and a price-induced reduction in demand in the non-household charcoal sector (see Annex 1 for assumptions). *This projection differs from the estimates published by the Beijer Institute*[5] *since it is corrected for an inadvertent error in the Beijer figures which had the effect of overstating year 1990 and 2000 firewood demand by 7.7% and 10.4%, respectively.*[6]

ENERGY PRICES

The relative availability and prices of charcoal and firewood, and their prices relative to kerosene, LPG, and other fuels, are the major determinants of each fuel's usage level. Government policy, which influences prices via price controls, taxes, tariffs, and distribution policy, has a major impact on conservation incentives, fuel choice, and the structure of the household fuel system. Similarly, the financial return on new firewood supply initiatives is dependent on the price received from the sales of wood or charcoal in the commercial marketplace.

Recent prices for charcoal and firewood for Kenya are shown in Table III-2. Table III-2 shows price components for four major urban centers, including the cost at the source, transport cost, wholesale price, and retail price. Several important features of the charcoal market can be observed from the table. First, it can be seen that the cost of charcoal is significantly higher when purchases are made in small units rather than by the sack. Most charcoal purchases appear to be made in small units in Kenya because of low household incomes. Second, charcoal prices vary significantly for different urban areas, based on

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[4] O'Keefe, et al., Energy and Development...; and Richard Hosier, Wood Energy and Households: Domestic Energy Consumption in Rural Kenya (Stockholm: The Beijer Institute, 1984).

[5] O'Keefe, et al. Energy and Development...

[6] H. Mike Jones, Charcoal Consumption Forecasts for Nairobi, Mombasa, Kisumu, and Nakuru--1980-1995, Working Paper (May 9, 1986); and O'Keefe, et al., Energy and Development..., p. 82, and pp. 95-96.

the quality of wood resources used and proximity of fuel.[7] Finally, as a note to the table indicates, charcoal fines and other waste in charcoal sacks raises the effective retail price by about 5%, narrowing the actual gap between per kilogram costs of charcoal purchased by the sack versus by the small unit.

TABLE III-2
CHARCOAL PRICES IN MAIN URBAN MARKETS--1985*
(in Kshs.)

Cost Item	Nairobi	Urban Market Center Mombasa (1 tonne = 1000 kgs)	Nakuru	Kisumu
Cost of Supply:				
Roadside price per tonne	557	499	540	790
Cost of Transport:				
Estimated average distance	196 km	80 km	100 km	122 km
Transport costs (Ksh./tonne-km)	1.72	2.75	2.26	1.94
Delivered Wholesale Price:				
Price per tonne	1232	939	993	1263
Retail Price:				
Average surveyed retail price per tonne				
Sold by the sack **	1487	1084	1121	1462
Sold in small quantities	1928	1150	1214	1550
Additional cost if bought in small quantity **	29%	6%	8%	6%
Official or controlled retail price sold by sack	1500	1200	1133	1200

Source: ESMAP, Peri-Urban Charcoal/Fuelwood Study, (1986).

* September 1985 prices, indicative of dry season pricing. Wet season retail prices are 10-40% higher.

** Does not reflect the fact that "fines" and other waste in sacks would increase the retail prices of usable charcoal by about 5%.

[7] For example, the Kisumu market is dominated by charcoal produced from sustained supplies of the East African Tanning Extract wattle plantations, while the Mombasa market appears to continue to have ready access to very high quality coastal wood resources.

In order to evaluate the potential viability of improved stoves programs as well as to consider other household energy questions, it is necessary to understand both trends in fuel prices and in firewood supply. Price and supply data in Kenya, however, are generally inadequate for energy planning purposes. The historic recording of charcoal prices in Kenya is a good example of the general problems encountered in locating and interpreting price data in many developing countries. Historic charcoal price records in Kenya are based on recorded prices per sack, but normally sacks have not been weighed by price surveyors. Sack weights have been found in various independent studies to vary both by region and to have significantly declined over the years (thought to be due to increasing scarcity of better tree species). *Thus, official price series tend to understate actual prices. Charcoal price series also have not incorporated any compensation to deal with the substantial variations resulting from seasonal (wet and dry season) price highs and lows.*

Figure III-1 below shows real charcoal prices in Nairobi separately and then combined and averaged with three other major urban centers in Kenya (Mombasa, Kisumu and Nakuru) with an adjustment for estimated declining sack weights.[8] With this adjustment, there appears to have been a moderate real price growth of about 4.7% per year for Nairobi and 3.4% per year for Kisumu, Nakuru, and Mombasa and Nairobi combined.

Another problem arises for kerosene price data. Kerosene (locally called paraffin) is a widely used substitute fuel for charcoal for some cooking, as well as a fuel for lighting in low income households.[9] Historic price series have recorded only officially regulated prices. However, due to extensive small-scale bulk purchase by dealers and then resale of kerosene in local shops (in urban as well as rural markets), market prices to the majority of ultimate consumers have been found to be anywhere from a factor of two to five times official prices.[10] *Historic price series for kerosene are therefore not useful for fuel substitution or other analyses. Another major factor affecting kerosene use is the observed unreliability of supply which creates spot shortages.*

Price series for electricity and LPG are more reliable bases for analysis as these energy sources are distributed primarily through regulated utility markets or regulated retail outlets directly to consumers. Comparison of the delivered cost of energy for electricity and LPG shows that each is considerably higher than charcoal (using the traditional jiko and charcoal purchased by the tin), about 70% higher for electricity and 118% for LPG.[11] The

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[8] The Nairobi average weight being reduced in a linear trend from 45 kg. per sack in 1971 to 37 kg. in 1985.

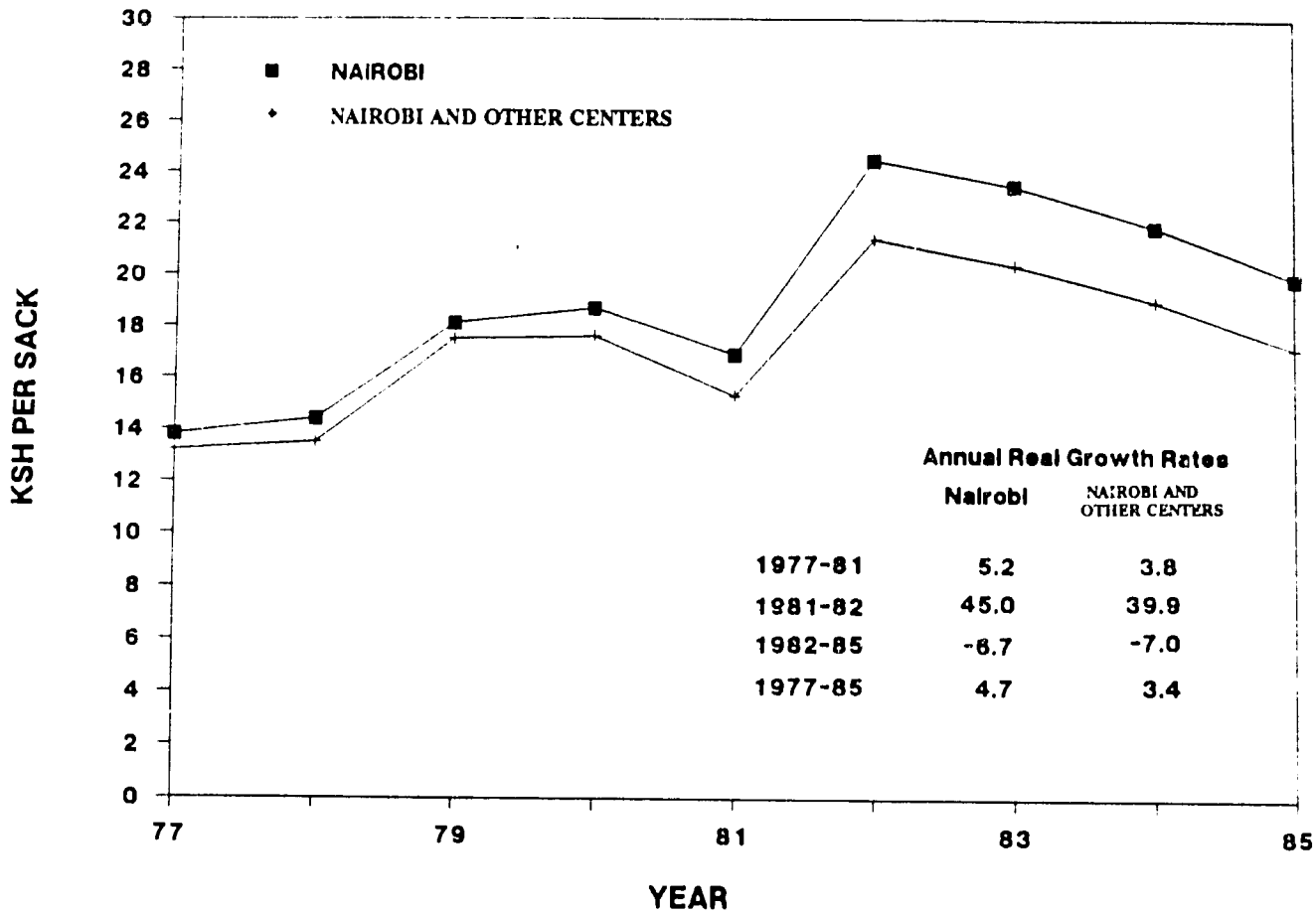
[9] Kerosene is a poor substitute for charcoal given the prevalence of small single-burner stoves. Kerosene use seems to be concentrated where rapid food preparation is desired, e.g., for morning tea or lunch. It is estimated that kerosene, even if more competitively priced, substitutes directly for about 40% of current cooking done with charcoal (i.e., roughly the portion for short-duration cooking).

[10] Central Bureau of Statistics, Informal Urban Household Survey (1986).

[11] This comparison is shown in detail in Annex 2 and takes into account the differences in heat content of fuels, device efficiency, and device cost.

substitution of these fuels for charcoal, given these large cost differences, appears to occur primarily with higher income as households shift to better "quality" fuels.

FIGURE III-1
CHARCOAL PRICES--NAIROBI AND OTHER CENTERS
(in constant currency terms)



While deficiencies in price data leave a great deal of uncertainty in the interpretation of historic price trends in Kenya, the basic conclusion appears to be that past charcoal prices and supply availability do not signify a current charcoal supply deficiency, but indicate increasing scarcity particularly in Nairobi. Substantial supplies still appear readily available from land clearing operations and the overall improved transport system has assisted in keeping prices from being pushed up very rapidly. Recent studies, however, do reach the conclusion that in the 1990s most remaining woodlands valuable for agricultural use will have been cleared, and at that time large-scale overcutting of highland catchment forest on steeper slopes and/or savannah range lands will take place for charcoal and firewood. If this occurs, it will result in both substantial environmental damage and greater escalation in the real price of charcoal and firewood.[12]

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[12] ESMAP, Peri-Urban Charcoal/Fuelwood Project, (1986).

CHARCOAL STOVE MARKET

An understanding of relative fuel prices and supply of fuels as described above is important to an understanding of all household fuel markets. An estimate of the prospective market for improved charcoal stoves is necessary for the design of an improved stove program and to help determine the likely location, size, and demand growth for both conventional and improved stoves. The estimated current and forecast market for charcoal stoves in Kenya shown in Table III-3 below is based on recent projections of household size and population growth for major urban and rural areas and on charcoal stove ownership estimates. Given the uncertainties in historic price data and the lack of time for a more refined estimate, this projection assumes a constant market share for charcoal. This forecast is used here for illustrative purposes only and should be more carefully prepared for use in the planning process. An estimated 65% of urban households and 14% of rural households utilize charcoal stoves.[13] Assuming a replacement of 1/2 of the stove population each year, a rough total annual market estimate is about 460,500 for all urban and rural areas in 1985 (see Table III-3). The market for urban areas which was about 280,000 in 1985, is estimated to have grown to 350,000 in 1988, with Nairobi accounting for about 60% of this amount or 207,000 (in 1988).

TABLE III-3
CURRENT AND PROJECTED ANNUAL
CHARCOAL STOVE MARKET IN KENYA

	1985	1990	2000
Urban areas	280,250	397,000	824,620
Rural areas	180,250	199,000	247,050
Total	460,500	596,000	1,071,670

The above market estimates demonstrate the significance of the rural market. about 180,000 stoves per year or about 39% of total. *These figures suggest that a comprehensive charcoal stove production and marketing strategy will need to devote much greater attention to non-Nairobi areas. This is not to say, however, that Nairobi will not remain the major production center for ceramic liners and serve as a model for production systems in other regions. As discussed later, initial concentration on this major market was appropriate and early efforts to disseminate the technology were not very successful. The complexity of*

[13] Central Bureau of Statistics, Rural/Urban Household Energy Consumption Survey (October/November 1978 and August 1980).

estimating stove markets and their importance for planning highlight the importance of careful assessment of markets prior to fixing a production and marketing strategy.

Conservation in charcoal use and/or shifts in the patterns of fuel use may have substantial impact on charcoal producers as well as charcoal consumers. It has been estimated that in 1985, market demands for charcoal created 30,000 full-time job equivalents for charcoal burners. Charcoal burning provides a significant source of supplementary household income in rural areas.[14]

ENVIRONMENTAL CONSIDERATIONS

One major and disturbing conclusion from the review of the Kenya charcoal supply system is our inability to identify the sources of wood used for charcoal. It is clear that consumption of charcoal requires immense quantities of wood. *The degree to which conservation would actually decrease biomass destruction, given the major effect of agricultural clearing and other factors, cannot now be determined. Better information to address this question is of importance to both conservation and supply programs and needs to be generated as soon as possible. There is clearly a disparity between private costs, which are represented by market prices, and public or social costs reflecting the cost of replacement as well as environmental consequences. Moderate market prices should not be taken as a true reflection of the social cost of charcoal.*

The lack of attention to the health effects of charcoal or wood consumption is another gap in the information available in Kenya. Attention is increasingly being given to the health effects of emissions from wood and other direct biomass use (not charcoal) for cooking and heating fuels due to evidence that these are important contributing factors in the high level of respiratory infections and chronic lung disease in developing countries. The rather disappointing fuel conservation results and implementation experience from most improved wood stove programs have, unfortunately, detracted from what now appears another important role for improved woodstoves, that is, reducing the adverse health impacts of traditional biomass cooking in developing countries.

Charcoal as a fuel has substantially different emissions characteristics and potential health effects than direct biomass combustion. Charcoal manufacture releases most particulate and hydrocarbon emissions and, therefore, the principal pollutant from charcoal combustion is carbon monoxide (CO). Carbon monoxide represents more of a safety hazard than a long-term health hazard and, as such, can be overcome relatively easily by cooking with charcoal in a well-ventilated location. As noted later in this report (Section V), the Kenya Ceramic Jiko appears to have a significant effect in reducing CO emissions.

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[14] ESMAP, Peri-Urban Charcoal/Fuelwood Project, (1985).

IV. ENERGY CONSERVING STOVES IN KENYA: DESCRIPTION OF PAST PROGRAM ACTIVITIES

BACKGROUND

A series of efforts beginning around 1980 were instrumental in identifying, developing, and introducing the KCJ in Kenya. This section describes this overall process and experience, emphasizing those activities financed by the Agency for International Development (A.I.D.) and beginning in 1981. The description here emphasizes the A.I.D. project due to the catalytic role that it played. This project was able to move improved stove efforts in Kenya from a poorly financed, ad hoc, and largely private voluntary activity, into the structure of a formal international donor-assisted project, and into a formal relationship with Government. In the description of activities which follows, the KCJ program is treated as synonymous with the KREDP project. Following the completion of the KREDP, KCJ activities became largely a private commercial activity, and no KCJ program as such has existed since that time.

KENYA RENEWABLE ENERGY DEVELOPMENT PROJECT (KREDP) --PROJECT DESCRIPTION

The KREDP was set up to assist the Kenya Ministry of Energy (MOE) and other government and non-government organizations, to

1. provide the basis for greatly expanded afforestation and improved forest management and improved wood/charcoal use efficiency;

2. stimulate development and dissemination of simple, low-cost, renewable energy technologies; and

3. help identify and implement measures to increase the efficiency of conversion and end use of petroleum fuels.

The KREDP was planned as a four-year project consisting of a grant of $4.8 million from A.I.D. and matching contributions in staff, facilities, and administrative support equivalent to $1.7 million from the Government of Kenya. The A.I.D. expenditure for the 24-month stove component of the project has been estimated at $160,000, with an estimated additional Government and other local contribution of about $45,000.[1] As a percentage of A.I.D. funding, this $160,000 for improved stoves (and charcoal kilns) constituted only about 3% of total KREDP funding versus an estimated 86% or $4.13 million for agro-forestry and $510,000 or 11% for energy planning and conservation.

The A.I.D. project was preceded by substantial non-governmental organization (NGO) and other private commercial activities. Of particular significance were the initial

[1] Estimate derived from figures supplied by the project contractor, Energy/Development International.

activities at Kenyatta University College (KUC), followed by the organization of a private "Claystoves Working Group" (CWG). These activities resulted in the preliminary testing of a number of improved stove designs and their demonstration at the 1981 U.N. Conference on New and Renewable Sources of Energy (UNCNRSE) in Nairobi. Although the CWG received no Government support, it generated both publicity and substantial information on potential improved stoves, stove testing, and production options. The original prototype of the ceramic jiko, the bucket stove from Thailand, was brought to Kenya by Keith Openshaw of the CWG. The working group, however, was severely handicapped by inadequate operating funds. It had no full-time staff and no Government-endorsed program. Its early efforts to promote production through a large-scale clay producer were, in fact, discouraged by Government. The group effectively ceased operations when the A.I.D./KREDP project was initiated, although the participants all remained active in other ways.

Technical Assistance in Charcoal and Wood Energy Conservation

Resources provided by the KREDP project included one biomass conservation adviser plus project management oversight and assistance, financial support for supplies and materials and field testing of improved stoves, and a small amount for short-term technical assistance. The project stove adviser was responsible for the following:

1. An informal survey of cookstove use and cooking methods, and of jiko and pottery makers' capabilities.

2. General technical assistance on improved stoves and charcoal kilns, curriculum materials and informational support; demonstration, extension and evaluation program assistance, and/or training; and dissemination of information on cookstove production methods.

3. Technical support to groups to assist small entrepreneurs who might want to commercialize new stoves.

4. Participation in formal courses and informal workshops to provide technical information and advice, and provide information clearinghouse services.

A program for charcoal conversion efficiency improvement was also planned but not implemented. It was to have been similar in approach to the above charcoal stove program.

Objectives of the Improved Stove Program

The KREDP project established certain performance targets for the improved stove project activity, which included

1. the introduction of at least 5,000 improved stoves in rural and urban poor households;

2. the building of technical capability in the MOE to identify, plan, implement, and evaluate improved stove programs;

3. the demonstration of improved stoves in at least 20 districts in Kenya;

4. the building of the capability among non-governmental organizations for involvement in stove programs; and

5. the establishment of a network of up to 20 self-sustaining stove production enterprises.

TECHNOLOGY SELECTION AND DEVELOPMENT

Survey of Stove Options and Comparative Evaluation

The KREDP initiated the stove development process with a survey of existing activities and an evaluation of potential improved charcoal and wood stove alternatives. Two brief related reviews were funded. The first examined ongoing cookstove production and dissemination activities in order to identify and document existing efforts to introduce improved stoves,[2] while the second reviewed previous efforts to transfer technology via extension and public/private cooperation.[3] Due to the perceived importance of the informal sector in any improved stove program, a brief survey and review of the informal cookstove industry was also undertaken separately.[4] Finally, unpublished field experience and a limited amount of published data were used from the Beijer Institute study of woodfuel in Kenya and the Central Bureau of Statistics. These data provided an overall quantitative understanding of the magnitude of fuelwood and charcoal use, their geographic distribution, and a description of household energy use characteristics.[5]

One of the major conclusions from the initial field studies and literature review was that concentration on urban charcoal stoves would be the most effective initial strategy. The approach adopted was to build on the existing infrastructure of traditional stove production, existing commercial marketing systems, and to concentrate initial work on Nairobi. The strategy recognized that to penetrate this market, the traditional stove would have to be displaced. This was to be accomplished by active involvement of the traditional stove producers in production and diffusion. Finally, the strategy excluded woodstoves which utilize primarily non-commercial

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[2] David Kamweti, A Review of Activities in Cookstoves and Kilns in Kenya, Kenya Renewable Energy Development Project (Nairobi: Ministry of Energy, 1983).

[3] Maxwell Kinyanjui and Susan Minae, A Strategy for Training and Extension in Renewable Energy Development, Kenya Renewable Energy Development Project (Nairobi: Ministry of Energy, 1982).

[4] Maxwell Kinyanjui and Gerald Chege, The Informal Sector Jiko Industry in Kenya: A Case Study of Shauri Moyo, Nairobi, (October 1983).

[5] Central Bureau of Statistics, The Rural/Urban Household Energy Consumption Survey: October/November (Republic of Kenya: 1978); and O'Keefe, et al., Energy and Development...

fuels. The development of appropriate stoves or conservation methods for non-commercial woodfuel use was felt to be much more difficult, and dissemination appeared to require the design of a major extension program not funded under the project.

Trip to Evaluate Thailand Stove

Since the KCJ based on the Thai bucket design appeared to be a good immediate possibility for introduction to Kenya, a study tour to Thailand was sponsored by the project to observe stove production and marketing. Participants included three individuals: the KREDP stove adviser, a potter, and the marketing manager from Clayworks, a large Nairobi clay tile producer interested in stove manufacture. *This trip to Thailand proved to be of critical importance. It served to clarify production techniques and scale, selection criteria for clay and other materials, and built confidence in the viability of improved stove enterprises in general.*

Improved Stove Selection Criteria

Early in the project, it was decided to adopt specific and pragmatic criteria for the selection of improved stoves, as well as a private sector-oriented approach to promotion. Criteria for the selection of stoves to be promoted were decided by the project team and represented a consensus. Improved stoves were to

1. be only an incremental step in technology and complexity;
2. involve only a moderate cost increase and produce clear and substantial financial benefits for the users;
3. use primarily existing production and marketing systems;
4. be adapted to traditional cooking methods and foods;
5. represent a clear quality improvement for the consumer;
6. use readily available materials and skills; and
7. offer significant profits and ease of manufacture for producers.

Laboratory and Field Tests

Stove prototypes were identified from within and outside Kenya and were selected for testing. These included several stoves designed by the Bellerive Foundation, one from the Kenya UNICEF program, a clay pipe stove, and an adaptation of the Thai bucket stove, among others. Tests were conducted at both the KUC and the Intermediate Technology Development Group (ITDG) Test Center at Reading University, U.K. Initial tests consisted primarily of water boiling tests to determine the percentage of fuel heating value utilized during a specified period of time to reach a boil and simmer a measured quantity of water. The testing program eventually led to the development of a set of agreed testing criteria

which were informally applied in Kenya.[6] The results of these tests indicated approximate thermal efficiencies of 20% for the traditional metal jiko (stove), 29% for the original KCJ, 25-30% for the clay pipe stoves, and 33-36% for the Umeme all metal stove.[7]

The lead role for the testing and development activities rested with the KREDP contractor and the project's local stove specialist, who acted as the project's technical expert. ITDG played a key role as a specialist in the laboratory testing of the stoves and as adviser on field tests. The KUC furnished test facilities and staff support for both laboratory and field tests, and Kenya Energy and Environment Non-Government Organizations (KENGO) provided advice on stove selection criteria and the field test team.

It should be stressed that the project did not rely primarily on these laboratory efficiency tests for stove selection. Screening via the seven criteria above were judged essential for acceptance of an improved stove design for further consideration. The Thai bucket type stove, later redesignated as the KCJ, proved to best meet all these above criteria at that initial stage. It is worth noting that although the all-metal Umeme stove designed by UNICEF was very efficient, it failed to meet project criteria due to its high cost and complex manufacturing requirements and the indications of only modest interest by consumers. A field test was also required for the ceramic stove before the stove was considered acceptable to the consumers (criteria 2, 4, and 5 above) and ready for dissemination.

The field test was designed by the KREDP stove adviser Maxwell Kinyanjui, ITDG's Stephen Joseph and Bill Stewart, and KENGO. KENGO was contracted by the project to undertake the field test. The field test also benefitted from the participation of a number of NGOs and other groups including Maendeleo ya Wanawake, the Undugu Society, the Christian Industrial Training Center, the Bahai community, and the Diocese of Maseno South. The field test was designed to

1. assess the social suitability of the stove;

2. determine if laboratory efficiency results were replicable in the field in actual use;

3. determine durability;

4. evaluate the technical suitability and economics of production techniques;

5. demonstrate the improved stove and increase public awareness of energy-savings opportunities; and

6. test the marketability of the stove and establish a prospective market price.

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[6] Stephen Joseph, Raphael Kapiyo, and Maxwell Kinyanjui, A Kenyan Standard for Charcoal Stove Performance (Nairobi: ITDG/Kenyatta University College, 1983).

[7] Stephen Joseph, Yvonne Shanahan, and Peter Young, The Comparative Performance of Kenya Charcoal Stoves, Stoves Project Technical Paper, No.1 (London: ITDG, 1982).

A sample of 450 households was initially involved in the test, with 100 surveyed in detail prior to the introduction of the stove to determine energy usage patterns. Half of this 100-household subgroup was treated as a control and half was used as a test group for the stoves.

The results of the field test indicated that the KCJ was achieving large charcoal consumption and financial savings (about 33%-55%) in the home, and that users were generally satisfied with the stove.[8] Manufacturing defects were encountered in many of the stoves, however, including loosening of the ceramic grate, grate breakage, and loosening of the ceramic liner from the metal stove shell. In addition, the initial stoves were considerably heavier than the traditional stove. Most of the participants were satisfied with the stove, however, and expressed a willingness to purchase the stove following the test.

Some redesign of the stove resulted from the test, reducing the weight of the stove and allowing for more of the surface area of the liner to come into contact with, and be cemented to, the metal cladding, to reduce earlier problems with separation. A significant effort was devoted to the modification of the Thai bucket type stove. These changes helped to adapt the stove to Kenyan cooking requirements (i.e., types of foods, pot stirring and pot size, pot weight, etc.), and established a design that would withstand normal handling and use. In adapting the Thai Bucket stove to Kenya's conditions, the following changes were made:

1. The clay pot rests were removed from the ceramic liner and replaced with metal ones resting on the metal cladding. This protected the liner from the heavier pots used in Kenya and simplified its construction by removing the need to carve the clay pot rests into proper shape (in Thailand, this process, known as stove cutting, requires relatively high skills).

2. Short legs were built to keep the stove from rocking on an uneven kitchen floor.

3. A tighter fitting inlet air door was installed to enable better regulation of power output. Standard meals in Kenya require both high and low power output at different cooking stages.

4. The metal casing was made out of the same heavier gauge sheet metal used for the traditional metal stove. Although this was unnecessary, stove buyers are used to associating stove durability with the heaviness of materials used.

5. The bucket-shaped metal cladding of the Thai stove was replaced with an hourglass-shaped one. Some meals require heavy mashing and stirring--forces

[8] Further discussion of stove savings under actual household conditions is given in Section V below.

that could easily topple a stove whose base area is smaller than the pan area.[9]

It should be noted that the ultimate weight, shape, production techniques, and metal shell are considerably different from the Thai stove from which the stove originally evolved. The need for potentially major changes in stove design for local cooking conditions, materials, skills, and other conditions is an important lesson from this experience.[10]

MANUFACTURING/DISSEMINATION ACTIVITIES

The KREDP project formally required the contractor to achieve the production and sale of only 5,000 stoves. It originally envisioned neither defining a dissemination program nor the significant support of commercial production. The project strategy which evolved redefined this modest objective in line with Government desires and promoted substantial private sector manufacture.

The project's promotion of commercial production was very limited due to the unavailability of funds set aside for this purpose and the difficulty of locating, and obtaining approval to support, what appeared to be viable producers. For this reason, the initial production of the KCJ was based largely on one small private sector company which had manufactured the initial improved stoves for KREDP field tests. It was expected that the selection of this manufacturer for initial prototypes would stimulate commercial production, which it did. The producer, Jerri International (small-scale local ceramics producer), had a long-standing interest in stove sales and a demonstrated entrepreneurial capability. Section VII describes the other attempts at production and draws lessons from this experience.

The basic premise behind the production and market development activities was that these activities needed to be self-sustaining once initiated, and that such activities were most likely to succeed if they involved a private sector firm or individual. The profit incentive was assumed to be the best means of assuring initiative and stimulating the investment of time and money by producers. It was not clear at the initial stage of the project what the role of the traditional jiko makers would eventually be, although it was Government policy to involve this group and the project staff strongly felt that this group had a useful role to play. It was several years after the project was begun, however, before central and municipal government support was practically manifested by legalizing artisan activities and structures in the Nairobi central artisan production area (Shauri Moyo).

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[9] Maxwell Kinyanjui, Final Report of the Cookstove Component of the Kenya Renewable Energy Development Project (Energy/Development International, 1984).

[10] Raphael Kapiyo, Development and Field Test of the Kenya Ceramic Charcoal Stove, Technical Report No. 1 (Nairobi: Kenya Energy and Environment Organizations [KENGO], 1983).

Technical assistance and financial aid were offered to only four entrepreneurs/enterprises by the project. Jerri International proved to be initially the most successful producer of ceramic jikos. Jerri is a successful ceramics manufacturer owned by a local entrepreneur who is also involved in several other enterprises. Jerri had one of the few well-trained local potters, together with a small but suitable production site and building containing storage area, potter's wheels, and an electric kiln. The owner had limited previous unsuccessful experience in trying to introduce clay stoves following the 1981 Nairobi UNCNRSE. Jerri received primarily technical assistance from the project along with an initial order of 450 stoves for field testing. *While the inputs to Jerri were not in the form of financing they were nevertheless critical. The inputs provided the essential previously missing ingredients, that is, clay mixtures and molding methods, appropriate insulation and stove design, and later an improved "bell bottom" external clay liner housing design.*

Another firm which was much larger and proved unsuccessful in its attempt to manufacture improved stoves was Clayworks. Clayworks is a large brick and tile manufacturing concern in the Nairobi area. At its own expense, the firm participated in the study tour to Thailand noted above and also participated in the earlier work of the CWG. Clayworks was officially restricted from receiving assistance from the KREDP project due to its large size and Government policy which favored the informal sector.[11]

Training. Once the KCJ was shown to save charcoal and meet with user acceptance, the Ministry of Energy strongly urged the KREDP staff to begin large-scale dissemination and promotion. The response was expanded artisan training based at agroforestry centers established by the project and field training of several prospective manufacturers. The manufacturers chosen had either ceramics experience, or the capability to organize production units. Informal sector businesses and artisans were traditionally engaged in similar stove manufacture in Kenya and, as such, were determined to be the appropriate scale for improved stove production. After the termination of the KREDP, non-governmental organizations, particularly KENGO, became very active along with the KUC in both further testing and evaluation of improved stoves, promotion of small-scale production, and training.

Market Development and Marketing. The project's demonstration activities were limited primarily to displays and comparison demonstrations at agricultural shows and some market day demonstrations. A conscious decision was made by project management to limit general publicity on the improved stove, since production capability was initially inadequate to meet rapid demand growth.

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[11] Clayworks' total production never exceeded about 21,000 units. Monica Opole, The Kenya Improved Cookstoves Programme: An Informal Survey of the Production, Sales [sic] of Programme Cookstove Field Activities (Nairobi: Energy/Development International, Kenya Renewable Energy Programme, n.d.).

INSTITUTIONAL ROLES

Government

The Ministry of Energy (MOE) had responsibility within government for the promotion and dissemination of improved charcoal and woodstoves and charcoal kilns. This role was to have involved various components including technical advice, training, and policy setting. The KREDP was implemented under the MOE with substantial working and administrative integration of the contractor staff within this ministry. At the same time, due to the lack of experience and limited staff at the MOE, important links were forged by the project team with both non-governmental organizations and other groups interested or involved in improved stove development and dissemination.

Non-Governmental Organizations

NGOs such as KENGO were organized at about the same time as the KREDP. KENGO was established initially as a nationwide coordinating body working in renewable energy. KENGO proved to be a useful vehicle for the KREDP to reach stove consumers via member organizations. KENGO has engaged in numerous activities subsequent to the KREDP involving charcoal stoves, woodstoves, and institutional stoves. Other non-governmental entities involved in stove activities of one type or another included UNICEF, Appropriate Technology International (ATI), the Appropriate Technology Advisory Committee, CARE Kenya, the National Christian Council of Kenya, the Bellerive Foundation, and others.

Kenyatta University Appropriate Technology Center (KU-ATC). The KU-ATC stove project began in 1977 in the Physics Department and later became part of the Appropriate Technology Center. The KU-ATC gradually became the major test center for MOE and other stove projects (due to lack of MOE facilities), and has played an important part in the activities of NGOs on improved stoves.

Other External Participation

Intermediate Technology Development Group (ITDG). ITDG, a United Kingdom-based organization supported by the Overseas Development Administration, collaborated extensively with the KREDP. The ITDG Stoves Project was set up to assist in training stove testing personnel and to assist in stove testing and in prototype development. Its inputs to the KREDP project are discussed further in Section VII below.

STOVE ACTIVITIES OUTSIDE THE KREDP/A.I.D. PROJECT

Charcoal Stoves

KENGO was the coordinating agency for the ATI (A.I.D.-sponsored) improved charcoal stove production-promotion project which followed the KREDP, together with Miaki Jikos, a local private concern. KENGO was responsible for the administration of the

project, transport support, and for monitoring, promotion, and liaison with producers. The project intended to stimulate 20 informal sector manufacturers to take up improved stove manufacture by providing technical and financial assistance. Miaki Jikos was to provide technical assistance and training and do the majority of the field work. The project was also to fund a small field test of a prototype improved wood stove (kuni mbili). This project is further reviewed in the Section VII.

CARE Kenya. Another attempt to expand the production of improved stoves and to improve both the ceramic and kiln technology was supported by CARE Kenya. This effort contributed to the introduction of a partially automated clay liner production technique (based on the technology earlier introduced by Hugh Allen of ATI) to standardize and increase production rates. This innovation is now in use in one major production unit.

UNICEF. UNICEF began a project in 1981 to develop a metal charcoal stove which incorporated improvements, such as a sunken pot design, while attempting to overcome relatively high cost. A relatively small number of stoves appear to have been introduced through this activity, and there continues to be small-scale commercial production. High unit cost and inconvenience of the recessed pot to the user limited the acceptance of this design. The activity has suffered from lack of funds for proper field tests and the lack of interest by producers in the complex design.

Bellerive. In 1980, the Bellerive Foundation of Geneva introduced a highly publicized "Micuta" (named after its developer) jiko for charcoal made out of heavy-gauge sheet metal and costing over Ksh. 200/-. This stove was intended to replace the traditional Kenya stove which cost about Ksh. 25/-. The Micuta jiko failed to gain widespread acceptance by manufacturers or households. This appeared due to high initial cost, unsuitability to family cooking patterns, and absence of any significant local follow-through and promotion.

Woodstoves

Household woodstove activities include various field tests of the Kuni Mbili woodstove funded by NORAD, CARE, and ATI. Work has also been undertaken to improve the stove design, including laboratory tests and modification in design done in conjunction with the Appropriate Technology Center at Kenyatta University.

GTZ-Maendeleo ya Wanawake Project. This project was begun in 1983-84 and has focused on rural wood stove development for five districts, including Lamu, Kisii Muranga, Kiambu, and Meru under the German Special Energy Program with MOE. The project has been unique in that its advisers have been integrated with a major Kenyan women's organization. The dissemination strategy includes owner-built and artisan-built stoves with the grates and fireboxes being supplied commercially. It is intended to involve Ministry of Agriculture technical assistants as extension agents for owner-built stoves. The project is attempting to achieve a self-sustaining, district-based activity concentrated on local women's groups.

Institutional Stoves

The Bellerive Foundation has been involved more recently in the introduction of a range of high-mass institutional stoves which are meeting with considerable success. KENGO has also been involved in the needs assessment and testing of institutional stoves under several grants. The first, by the International Development Research Council (IDRC), involved a one-month field assessment of institutional stove requirements. Subsequently, IDRC provided a grant for KENGO to undertake research, testing, and development of institutional stoves.

V. CHARCOAL FUEL SAVINGS FROM THE KCJ

BACKGROUND

The original motivation for the KCJ program in Kenya was to save charcoal in order to contribute to reduced deforestation as well as to lower consumer expenditures on fuel. The effectiveness of improved stove programs in reducing deforestation has been questioned by some observers and three main points have been advanced. First, agricultural clearing and not energy consumption is claimed to be the primary culprit in deforestation. Second, laboratory fuel savings rates on the order of 25 to 50% for improved stoves are not duplicated in households, where people operate the stoves less carefully and under less than optimal conditions. Finally, some authors have argued that initial fuel savings will generate higher incomes and lower charcoal cooking costs, both of which tend to increase charcoal consumption, and partially or completely offset the technical savings from the improved stove.[1]

In the Kenyan context, the first of these objections to improved stove programs must be addressed for the major urban markets by examining the specific sources of charcoal. Unfortunately, existing data are inadequate to identify sources clearly and the impacts of conservation on these sources. What little evidence exists indicates a significant contribution from both agricultural clearing operations and wood cut explicitly for charcoal production. Which process predominates in an area depends on the agricultural potential of the land, population pressures, and the area's proximity to urban charcoal markets. Therefore, household charcoal savings from improved stoves reduce deforestation only roughly in proportion to the volume of trees felled primarily for making charcoal.

The actual realized savings from using an improved stove in the home as well as income and substitution effects, the bases for the latter two objections above, can be accounted for at the household level. Indeed, it is the net effect of all technical and economic influences on charcoal consumption that is observed by comparing charcoal consumed before and after purchasing an improved stove. Separating the various consumption effects--the reduction due to greater stove efficiency, the diminution of savings from improper stove use, and the impact due to income or substitution effects on initial charcoal savings--is the more difficult task. After reviewing consumer fuel and stove use patterns, this section examines and analyzes data on the joint effect of all these three influences, which is all that present information allows. Suggestions are made for examining the effects separately in future work.

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[1] Income and substitution effects refer to increased consumption of charcoal due to the increase in available income due to lower charcoal purchases as well as due to people substituting away from other relatively more costly fuels.

The section finds, in summary, that net charcoal savings do occur in Kenyan households that use the KCJ. The Nairobi household using 955 kg of charcoal per year at a cost of KSh. 1748/-, would save on average KSh. 350/- annually. These savings would repay higher stove costs of about KSh. 43/- for the most popularly sized KCJ in only seven weeks. This KSh. 350/- is equivalent to about 1/2 of one month's income for a low income household with annual earnings of about KSh. 8,400/-. Such benefits do not account for the fact that the KCJ also lasts longer, and they do not include nonmonetary benefits such as increased cooking speed, lower soot emissions, and lower risk of burns.

FUEL AND STOVE USE PATTERNS

Several studies have examined consumer fuel and stove use patterns and the potential savings from the Kenya improved charcoal stove. In 1982-83, during KCJ development, KENGO conducted a field test of the improved jiko.[2] The second major effort at gauging the impact of the KCJ was undertaken as part of a multi-country assessment of wood stove programs undertaken by the FWD in 1986. The Kenya component of the multi-country assessment was also done under the auspices of KENGO.[3] KENGO's consultant conducted two residential sector investigations: an 1100-household cross-sectional survey in Nairobi and Kisumu, in which people were asked about type(s) of stove used and their charcoal consumption; and an "intensive" survey of 50 households in two days of cooking per household.

Overall, charcoal is the most important fuel for low and medium income urban households in Kenya, comprising a major proportion of some household budgets. In 1982, for example, a typical lower income household earning KSh. 700/- per month spent from 15% to 25% of its income on charcoal.[4] Figure V-1 indicates the urban cooking fuel patterns in Kenyan households as shown in a 1981 survey of energy consumption by household in Nairobi.[5] This 1981 survey was conducted as part of the Beijer Institute-Ministry of Energy Fuelwood Cycle Study, and while fairly old, remains the most recent detailed survey available with information on the distribution of household energy consumption in Nairobi. A sample of 467 households was interviewed in over 55 distinct housing estates, with stratification oriented toward obtaining a representative sample of each of six income groups. These categories have been aggregated in three groups in Figure V-1. With adjustment to bring 1981 household incomes up to equivalent 1985 Ksh. currency levels, income groups shown are: Group 1) Ksh. 0 - 1,528, Group 2) Ksh. 1,529 -

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[2] Raphael Kapiyo, Development and Field Test of the Kenya Ceramic Charcoal Stove, Technical Report No. 1 (Nairobi: Kenya Energy and Environment Organizations [KENGO], 1983).

[3] Sylvester A. Namuye, Survey on Dissemination and Impact of Kenya Ceramic Jiko in Kenya (Nairobi: Kenya Energy and Environment Organizations [KENGO], March 12, 1987, revised July 1987).

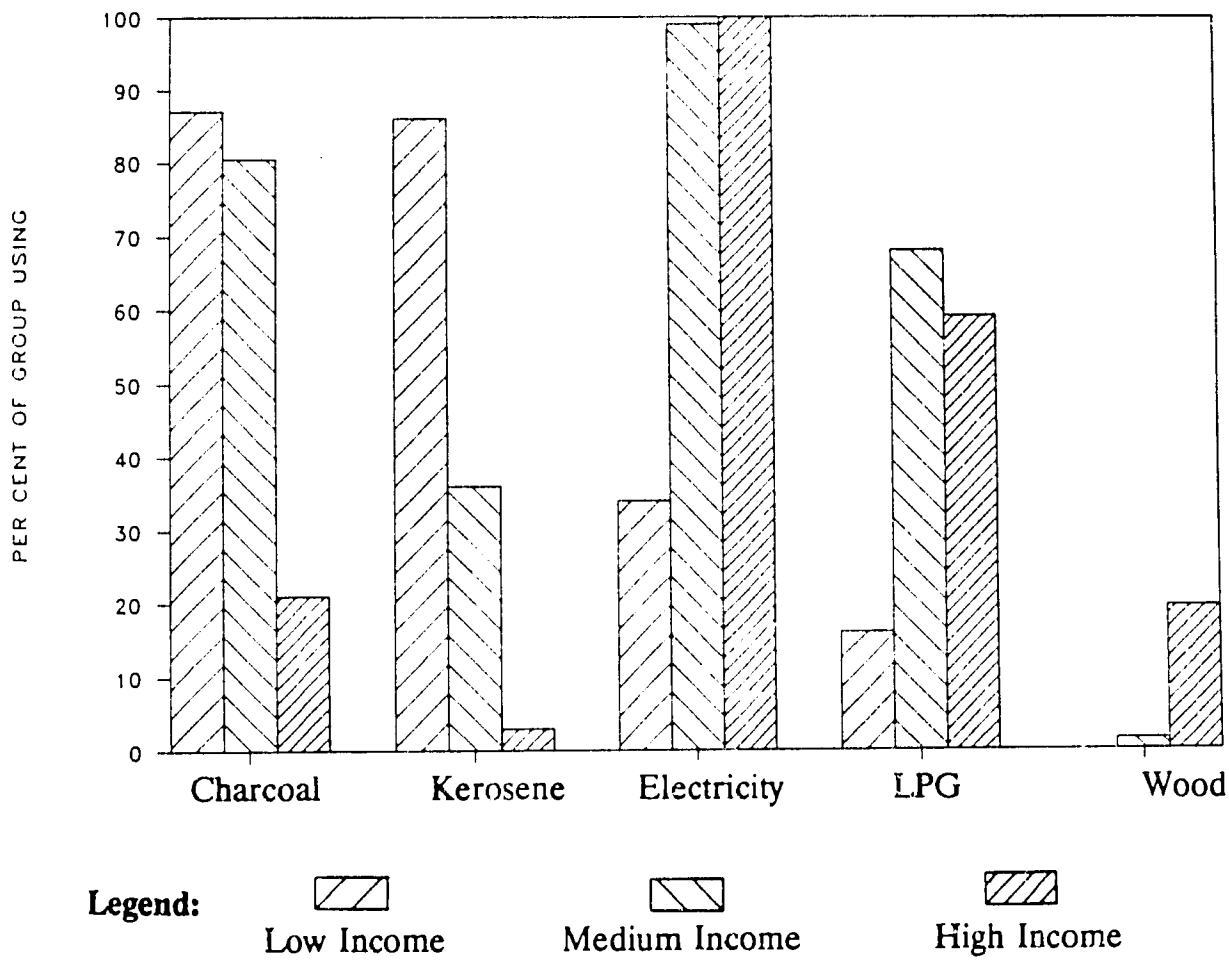
[4] Kapiyo, Development and Field Test..., p. 29.

[5]. Ellen L. Hughes-Cromwick, Nairobi Households and Their Energy Use: An Economic Analysis of Consumption Patterns (London: Butterworth and Co., 1985).

8,495 and Group 3) Ksh. 8,500 and above.

The patterns of consumption in Figure V-1 show that over 80% of low and medium households are charcoal users. Kerosene use is highest in the lowest income category (about 86%), with use equally for cooking and lighting; with significant use in the medium income group (about 36% of households), primarily for cooking. Electricity use was lowest for the low income group, being primarily for lighting where used, but was used by virtually all in the upper two income groups, primarily for lighting, cooking and water heating. LPG was a major fuel for both of the higher income groups, but only of minor significance for low income households. Finally, wood was used primarily by the higher income urban households, who use it for space heating. The relatively high cost and inconvenience of wood in urban dwellings makes it relatively rare as a fuel, at least in Nairobi.

FIGURE V-1
FUELS USED BY INCOME GROUP *



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* Distribution of fuel use by income group from the 1982 Field Test and 1986 FWD Study were not sufficiently representive of the overall population to be used for the above comparisons.

Other uses of charcoal in Kenya include water heating and some space heating. Warm water heating using charcoal is performed by approximately three-quarters of households in all income groups, according to reanalysis of FWD data from Nairobi and Kisumu. In surveys performed in Nairobi and Mombasa during the Field Test and in Nairobi and Kisumu during the FWD Study, indications are that space heating in Nairobi is quite prevalent during the cold season, moderately so in Mombasa, and done very little in Kisumu. Charcoal use for space heating decreases as income goes up, possibly being replaced by other fuels in the upper income groups. Table V-1 gives percentages of households that space heat during some part of the year according to the two surveys.

TABLE V-1
CHARCOAL USE FOR SPACE HEATING BY INCOME GROUP
(% of households surveyed)

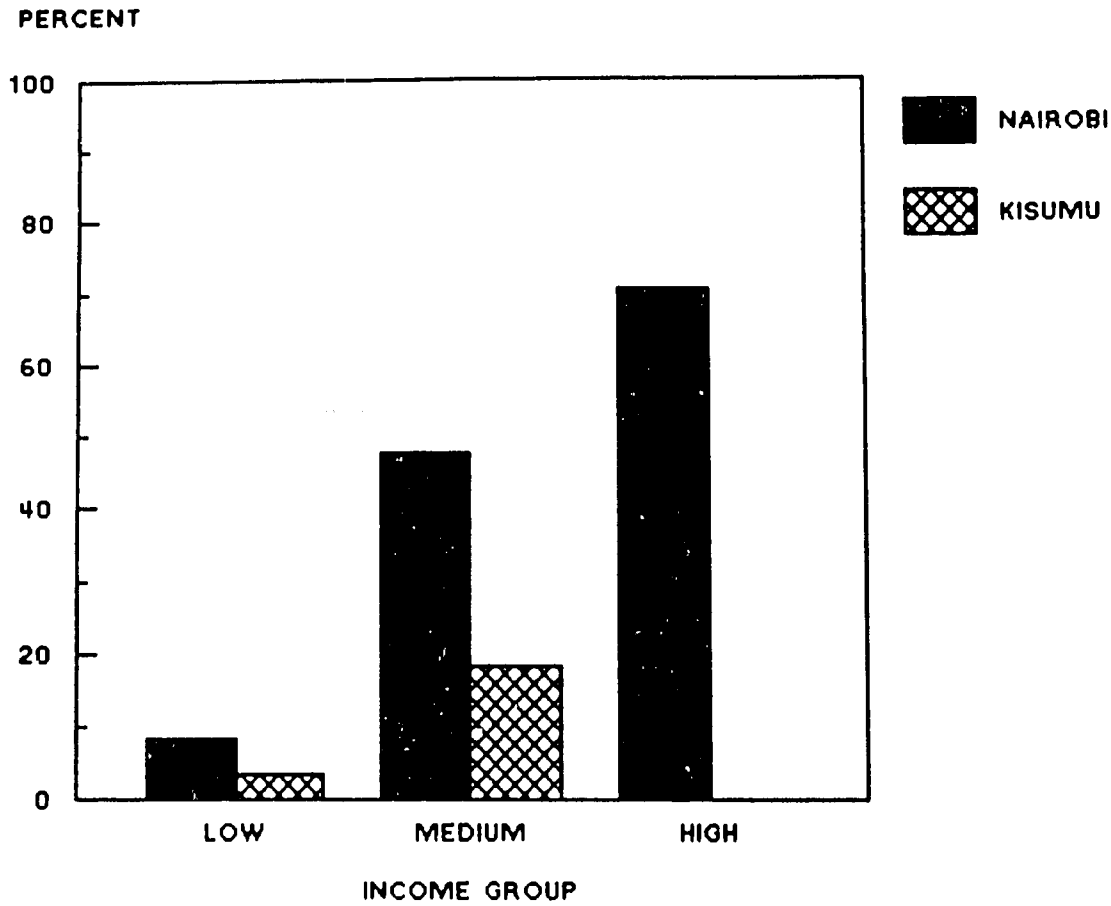
Income Group	FWD Study Nairobi	Field Test Nairobi	Field Test Mombasa	FWD Study Kisumu
Low	55.9%	74.0	40.0	2.5
Medium	44.4	66.0	12.9	2.6
High	35.3	55.0	0.0	0.0

Sources: Reanalysis of raw data from 1982 Field Test and 1986 FWD Study.

Because the KCJ carries a price premium over the TMS of KSh. 25/- to 40/-, it has been more readily adopted by the middle and high income groups than by its original target, the low income group. Figure V-2 indicates the adoption rates from the FWD Study sample in 1986. As can be seen, ownership rates increase as income rises, particularly in Nairobi (from 8% to 48% to 71%). This is true despite the fact that charcoal cooking decreases in the high income group. In Kisumu, ownership increases from 3.5% in the low income group to 18% in the middle income group.[7] Besides the charcoal savings that the KCJ affords, members of the middle and upper income groups purchase the stove because of its aesthetic appeal, the regularity of charcoal supply in contrast to the irregularity of LPG supplies, and because some foods can only be cooked on charcoal.

[7] Figure V-2 shows no ownership percentage for the Kisumu high income group, because there was only one observation in this group.

FIGURE V-2
KCJ OWNERSHIP BY INCOME GROUP



ANALYSIS OF KCJ CHARCOAL SAVINGS

During the Field Test, 76%, 79%, and 60% of the persons interviewd in the low, medium, and high income groups, respectively, expressed dissatisfaction with the traditional metal stove.[8] Their main reason was its high charcoal consumption rate. This section turns to an analysis of the effectiveness of the KCJ in saving charcoal.

The 1982 Field Test and the 1986 FWD Study provide valuable data for assessing charcoal savings from the KCJ. Besides consumer reactions to the jiko's design, the Field Test asked questions about charcoal consumption before and after the KCJ was placed in the household. In the FWD Study, people were asked about type(s) of stove used and their

[8] Kapiyo, Development and Field Test..., pp. 18-20.

charcoal consumption. From the Field Test data, before and after comparisons of charcoal use can be made, while from the FWD Study data, with and without comparisons can be made.

It should be mentioned that weaknesses in study methodology and data collection occurred, which reduce confidence in these results. First, both studies--with the exception of one component of the FWD-funded survey--relied on respondents' mental recollections of charcoal usage rather than weighing actual amounts of charcoal used. Neither study seems to have followed a rigorous random sampling regime. The 1982 Field Test showed a disproportionate number of people with higher than average educational and occupational statuses. The FWD 1100-household cross-sectional survey concentrated on lower and medium income areas in Nairobi and Kisumu, and did not utilize proper sample frames to ensure a representative sample across income groups and geographic areas. Moreover, surveyors were allowed to choose households to interview, rather than relying on stricter selection criteria. Both surveys relied on observation to classify households into income groups. The Field Test did not ask questions about charcoal use rates in its second follow-up survey after six to eight months of use, which would have given a better picture of long-term adjustments to KCJ use and consequent fuel savings. Finally, the component of the FWD study in which charcoal use was measured suffered from a small sample size of 50 households, only 30 of which used the KCJ.

While these weaknesses do not appear to invalidate many of the studies' results, they do make population-wide estimates of KCJ penetration unreliable. Moreover, charcoal savings rates from both studies should not be viewed as highly accurate point estimates because they are calculated from approximate recollections of charcoal use. Nonetheless, the data exhibit consistent tendencies and statistically significant results that allow broader conclusions about whether the KCJ saves charcoal and the general magnitude of these savings.

Rather than simply relying on results given in the 1982 Field Test and FWD Study reports, the authors of this report reanalyzed the raw data available from these studies. Reanalysis was desirable to utilize better statistical methods and to remove many earlier inconsistencies in the data.

Results from Analysis of 1986 FWD Study Data

The 1986 FWD Study survey data include a cross-section of households, allowing comparison between households that use and those that do not use the KCJ. The FWD Study data differ from the 1982 Field Test data in that the same households were not interviewed with and without the KCJ.

In the FWD Study report,[9] an attempt was made to account for variables that can affect a household's charcoal consumption statistically by dividing family size into charcoal use per household and computing averages of the results for various income groups. This

[9] Namuye, Survey on Dissemination and Impact...

goes part of the way toward accounting for variations in charcoal use rates, but more variables can be held constant while examining the differences between TMS and KCJ charcoal use rates by using regression analysis. Accordingly, after correcting many data anomalies in the FWD data set, regressions were used to "explain" the amount of charcoal used per household. Independent variables in the equation included the number of adults and the number of children in the family (i.e., family size), income group, the type(s) of stove(s) used, number of meals cooked per day, the price paid for charcoal, and whether charcoal was used for water heating, space heating, or other applications in the household.

The primary result of interest was whether KCJ use reduced the amount of charcoal use in households. By definition, the coefficient on a regression variable indicates the effect of that variable on the dependent variable, in this case charcoal consumption, *holding all other variables constant.* If the variable indicating KCJ use in the regression equation is negative, this indicates lower consumption of charcoal for households that use the KCJ. As Table V-2 indicates, this was the case for two types of regressions calculated (i.e., one including all stoves used by a household and a second including the stove most used by a household) in both cities sampled.[10] The interpretation of the coefficients in the first two lines of Table V-2 is that, all other things equal, a household with a KCJ would use 0.45-0.52 kg per day less charcoal than a household without one (whether or not it had a TMS). The interpretation of the second two lines is that a household that uses a KCJ as its primary cooking device would use 0.66-1.19 kg per day less charcoal than a household that uses primarily a TMS. Across all four regressions, the amount of charcoal saved per day varies from 17% to 39%, with three of the regressions indicating savings in the 17% to 25% range. These results support the conclusion that the KCJ saves fuel, but perhaps not the 30% to 50% so often cited.[11]

Unfortunately, only the large, 1100-respondent questionnaire survey data were available from the 1986 FWD Study. Both the computer files and the original questionnaires from the intensive survey had been lost. Therefore, an FWD synthesis report prepared by Stephen Joseph[12] must be relied upon for results of the intensive survey. It can be concluded at the 5% confidence level, Joseph indicates, that a net decrease in fuel consumption occurred with the use of the new stove. Mean fuel consumption for the TMS was 0.67 kg/person/day while for the KCJ it was 0.39 kg/person/day, a 31.3% savings for the same meals cooked in the same households. He further reports that in Kenya and the other countries examined, there was a strong correlation between users' perceptions of savings and measured figures, which lends greater credence to the results reported in Table V-2.

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[10] See Annex 3 for full regression results.

[11] It should be reiterated that the savings estimated by these equations include any offsetting increases in charcoal consumption due to income and substitution effects of KCJ savings, although further such effects may occur if larger market sales of KCJs depresses the price of charcoal.

[12] Stephen Joseph, An Appraisal of the Impact of Improved Wood Stove Programmes: Synthesis of Experience (Sydney, Australia: BEST [Biomass Energy Services & Technology], no date).

TABLE V-2.
KCJ REGRESSION COEFFICIENT AND PERCENT SAVINGS IMPLIED FOR 1986 FWD STUDY

City	Type of Stove Variables incl. in Equation	Estimated Coefficient on KCJ Use	Mean Charcoal Use for Sample (kg/hsehld/day)	KCJ Savings Implied
Nairobi	All stoves used	-0.449*	2.618	17.2%
Kisumu	All stoves used	-0.515	3.054	16.8%
Nairobi	Stove most used	-0.657*	2.616	25.1%
Kisumu	Stove most used	-1.194*	3.054	39.1%

*Significant at .05 level in a one-tailed test.
Source: Reanalysis of raw data from 1986 FWD study.

Results from Analysis of KCJ Field Test Data

The original Field Test data involved interviews with the same households before and after they embarked on KCJ use. These, therefore, represent a comparison of use rates between the TMS and the KCJ holding other independent variables such as household size, income, and food preferences constant.[13] For this reason, sophisticated statistical techniques were not necessary to separate the effect of KCJ use from other factors that could affect charcoal consumption. Instead, simple averages of charcoal savings in households by income group and city were calculated.

Savings estimates in this survey were derived from two different sets of consumer responses. The first savings estimate is based on the difference between the charcoal use reported in the Field Test's pre-survey of households and the charcoal use reported after using the KCJ for three months. The second savings estimate is based on the same sample, but utilized the difference between the recollection of charcoal use three months earlier (using the TMS) and the amount being used with the KCJ when the question was asked, both questions being asked during the follow-up survey. In both cases, a savings rate (or increased consumption rate) was calculated for each household, and these were averaged over households to obtain the statistics reported in Table V-3.

As Table V-3 indicates, the average overall savings rates were 42% and 46% for the two types of averages, respectively. Average savings rates for subsamples broken down by

[13] It does not hold constant the use of other cooking appliances, such as kerosene and LPG stoves, because these devices may have been used more or less as the people adjusted to the KCJ over the three month testing period. More on this below.

income group and area range between 25% and over 50%. The savings calculated based on the difference between pre-survey and follow-up survey may be considered more accurate because they are based on reported use at the time the question was asked, while the savings calculated on the basis of answers given strictly in the follow-up survey may reflect people's perceptions about what they are saving. Despite differences of interpretation, it is clear from Table V-3 that people believed they reduced their charcoal consumption by an average of 40 to 45% by using the KCJ.

TABLE V-3
AVERAGE CHARCOAL SAVINGS RATES
FROM KCJ FIELD TEST DATA

	TMS in Presurvey to KCJ in Follow-up		TMS Recollection to KCJ in Follow-up	
	Cases	Savings (%)	Cases	Savings (%)
WHOLE SAMPLE	246	42.4	247	46.2
Low Income				
Nairobi	115	44.9	114	48.1
Mombasa	19	43.8	19	44.8
Both Cities	134	44.7	132	47.5
Medium Income				
Nairobi	77	41.8	79	42.9
Mombasa	23	28.1	24	49.6
Both Cities	100	38.6	105	44.4
High Income				
Nairobi	6	56.8	5	51.0
Mombasa	6	40.3	6	41.0
Both Cities	12	48.6	9	46.4

Source: Based on reanalysis of raw data from Kapiyo (1983).

Savings indicated by the 1982 Field Tests are considerably above the 17% to 25% indicated by the 1986 FWD Study, and also above the 31% savings from the 1986 FWD Study intensive survey. The difference might be explained by the manner in which the questions for the Field Test were asked. After three months of use, respondents were asked, "How much charcoal and [at what] cost were you [using] before and after getting the new jiko?" Because most people buy charcoal in small units (tins), answers tended to bunch around numbers of tins that indicated an effective savings rate of 50%, e.g., two tins per day before and one tin per day after. This may seriously bias estimated savings rates upward. For this reason, the savings rates based on the FWD data, in which households were only asked about current charcoal consumption rates, and comparisons were performed statistically, and a second case, where detailed measurements were made, are probably more accurate.

DETERMINANTS OF CHARCOAL CONSUMPTION

The regressions utilizing the FWD Study data that permitted estimation of charcoal savings from the KCJ also can be used to examine other determinants of household charcoal consumption. Since four separate regressions were estimated, there will be four slightly different interpretations of the magnitude of the effects of various determinants. However, the regression for Nairobi in which all stove types used by a household were included (as opposed to the stove type used most by the household) may be taken as representative.

Figure V-3 gives graphical representation of the most important socio-economic determinants of charcoal consumption, including price, income, and family size. A price rise of Ksh. 1/- per kilogram of charcoal would depress average household consumption by 0.69 kg per day. As the figure shows, the relationship between income and charcoal consumption in Kenya is that as income rises from the low to the middle income group, charcoal consumption rises; as income rises further to the level of the high income group, charcoal consumption declines. With the low income group as the base case (having no effect on mean, daily household charcoal consumption), membership in the medium income group has a positive effect of 0.18 kg per day, and membership in the high income group causes an adjustment of -0.67 kg per day.

Finally, the marginal effects of adding an adult or a child to the average sized family in Nairobi (2.9 adults, 2.9 children) are shown in Figure V-3. An additional adult increases charcoal consumption 0.25 kg per day, an additional child slightly more, at 0.29 kg per day.

Figure V-4 shows the effects on charcoal consumption of using various stove types as well as using charcoal in noncooking applications such as space heating and warming water. Using the TMS increases charcoal consumption only slightly above the sample mean daily household consumption--by an amount imperceptible in Figure V-4. This minute rise above the mean is probably because use of the TMS is still standard practice in Nairobi, and mean charcoal use is represented by households that use the TMS. The next lowest bar indicates the primary result of the charcoal savings analysis--that use of a KCJ in the

FIGURE V-3
EFFECTS OF SOCIO-ECONOMIC VARIABLES ON CHARCOAL CONSUMPTION IN NAIROBI

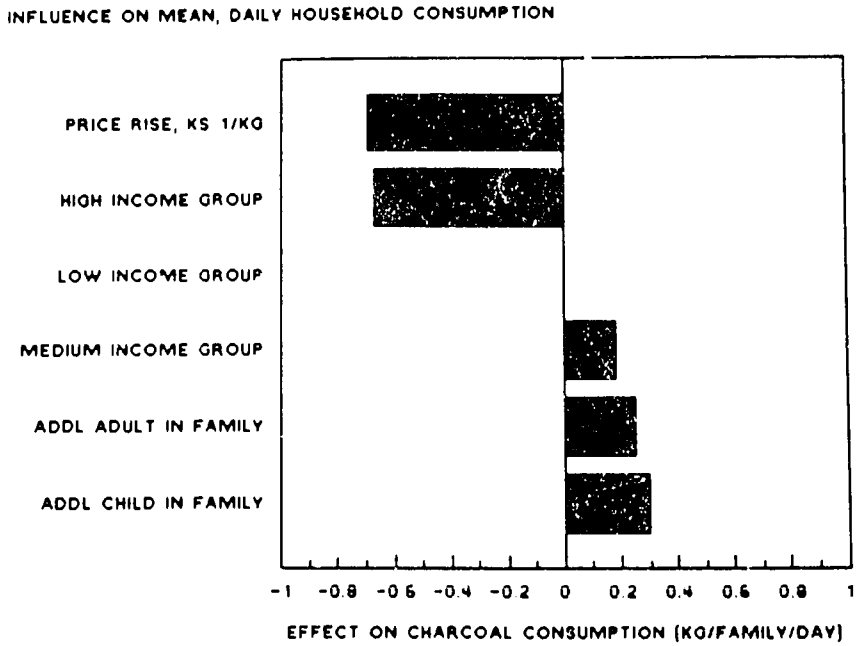
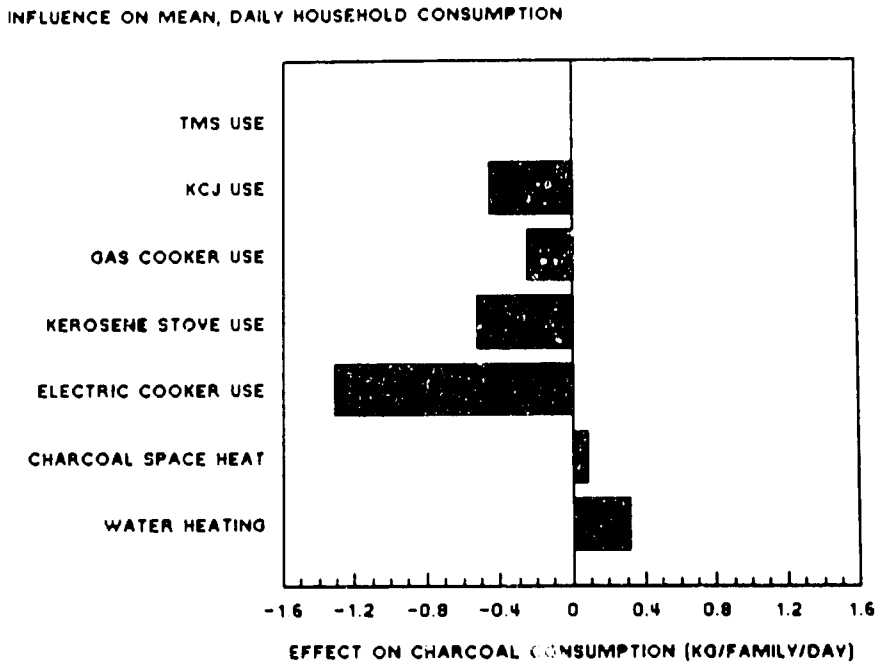


FIGURE V-4
EFFECTS OF USING VARIOUS STOVES AND CHARCOAL APPLICATIONS ON CHARCOAL CONSUMPTION IN NAIROBI



household reduces charcoal consumption by 0.45 kg per day from the average (2.62 kg/day in this sample).[14] The next three bars indicate that gas cooker use, kerosene stove use, and electric cooker use all decrease charcoal consumption in a household, the magnitude of the effect being increasing in the order given. A possible reason for the electric stove having such a great impact on charcoal consumption, which is a bit odd, is that the high income group contains the main users of electric stoves. The correlation between their low charcoal consumption rates and their use of electric stoves may be spuriously magnifying the negative effect of using an electric stove on charcoal consumption.

Finally, use of charcoal for space heating and for warm water heating are seen to increase charcoal consumption above the mean by 0.08 kg and 0.31 kg per day, respectively. The lower effect of space heating may result because of the seasonal nature of space heating. However, the meaning of the space heating coefficient is also questionable, since people were simply asked how much charcoal they purchase and at what frequency; depending upon the season in which the question was asked, the enumerators may not have been collecting answers that include an effect for space heating.

OTHER BENEFITS OF IMPROVED CHARCOAL STOVES

The 1982 Field Study and the 1986 FWD Study found consumers recounting a number of other benefits of the KCJ besides charcoal and monetary savings, although these latter remained at the top of the list. Laboratory testing also indicated certain health benefits. These other gains include the following:

1. Cooking speed was viewed as faster than on the TMS by 96%, 84%, and 96% of the low, medium, and high income groups, respectively.[15]

2. Soot emissions are reduced. The 1986 FWD Study reports that lowered smoke emissions were cited as contributing to a cleaner and healthier kitchen environment for lower income households.

3. Carbon monoxide emissions. Laboratory tests at Kenyatta University College and the University of Nairobi indicated that carbon monoxide levels decreased 20% when switching from the TMS to the KCJ. More recent in-home emissions tests sponsored by the GTZ indicate substantial reductions in overall emissions with the KCJ, although results are too preliminary to give numerical estimates.

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[14] Recall that 0.45 kg/day savings was for the Nairobi regression that included all stove types in the equation. Other estimates ranged from 0.52 kg/day to as high as 1.19 kg/day, for Kisumu and the other type of regression (in which the stove most used was included in the equation). Mean charcoal consumption was also higher in Kisumu, at 3.05 kg/day.

[15] Kapiyo, Development and Field Test..., pp. 39-40.

4. Risk of burns is reduced for adults and children alike, because the clay liner reduces heat transfer to the outer metal cladding. Almost 100% of households owning the KCJ in the 1986 FWD Study mentioned this advantage.

5. Durability of the KCJ is greater than that of the TMS. The KCJ is estimated to last 18 to 24 months compared to 12 months for the TMS.[16] The KCJ ceramic grate must be replaced every 8 to 12 months, while the TMS metal grate must be replaced every 3 months.[17]

6. Portability of the TMS was retained in the KCJ. Even though the KCJ is heavier, it can still be moved with little effort by adults and some effort by children.

7. Aesthetically the KCJ is more appealing. Its bell-bottom shape and the fact that many manufacturers paint the KCJ has made it an attractive item to households at all income levels.

8. Status symbol. Due both to the KCJ's appearance and to its being considered something modern, the KCJ is a status symbol in many housewives' kitchens.

9. The reliability of charcoal fuel supply in comparison to less reliable kerosene and LPG supplies, has caused some middle and high income consumers to use the KCJ and depend more on charcoal for their cooking than before.

INCOME AND SUBSTITUTION EFFECTS

The KCJ has been shown to produce technological (i.e., laboratory) charcoal savings of approximately 30 to 50% over the TMS. This is the direct or primary effect on household charcoal consumption engendered by the use of the KCJ. Besides the technological savings, however, a number of indirect or secondary economic effects can be identified that may offset--or in some cases reinforce--the primary effects of charcoal savings. Such indirect effects occur both in the residential and the producer (i.e., the commercial/light-industrial) sectors.[18]

The technological savings of the KCJ may cause an income effect among residential consumers because reduced charcoal use in a household effectively increases the family's income. The increased income may cause the household to slightly increase its purchases

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[16] Namuye, Survey on Dissemination and Impact..., p. 37.

[17] Eric Hyman, "The Economics of Improved Charcoal Stoves in Kenya," Energy Policy (April 1986), pp. 149-158.

[18] Donald W. Jones, "Some Simple Economics of Improved Cookstove Programs in Developing Countries," unpublished draft (Oak Ridge, Tenn.: Energy Division, Oak Ridge National Laboratory, April 1988).

of charcoal, partially offsetting the technological savings. The technological savings also produce a substitution effect. The decreased amount of charcoal used makes charcoal cooking less expensive than it was before, and users may substitute toward more charcoal cooking and away from other types of cooking. Moreover, the substitution effect may not only be based on the purely financial effect of charcoal savings, but also include a shift to the KCJ due to its lowered risk of burns, cleaner cooking environment, less frequent charcoal charging requirement, and other benefits it provides.

In addition to these income and substitution effects, lower charcoal use by many households using the KCJ will, in the long-run, reduce the market demand for charcoal. As a consequence, its real price would be expected to decline, or at least not advance as quickly. This will produce a second round of income and substitution effects, because the lowered price effectively increases the purchasing power of consumers' incomes and because people generally substitute toward cheaper goods.

It is important to note that the income and substitution effects are subsumed in the results given above. Reported charcoal savings are net savings, i.e., technological savings less any offsets for income and substitution effects. This is true with the exception that further real charcoal price declines due to more widespread KCJ use would induce further income and substitution effects. Unfortunately, lack of data prevents verification of the probable magnitude of long-run income and substitution effects as well as what component of current savings is an offset due to these effects. The importance of income and substitution effects will undoubtedly remain a point of contention between proponents and skeptics of improved stove programs, and developing the data to estimate them is important (See Future Work below).

A second category of indirect effects lies in the producer sector of the economy. Charcoal is an input to certain commercial and light-industrial processes, and a change in its price will affect the demand for charcoal by these users. The demand for charcoal by these users will change for two reasons. First, due to both types of income and substitution effects among consumers, consumer demand for goods produced in the commercial and light-industrial sectors will change. In industries that use charcoal, this change in the demand for their outputs will change the demand for charcoal. The second producer indirect effect is a substitution toward more charcoal as an input in the production process because it is now cheaper, and away from other inputs that, relatively speaking, have become more expensive.

In a section below, we describe how to estimate these effects in future work. In the next section, however, we review some impressions about potential substitution effects in households based on the Field Test data.

OTHER CHARCOAL USE IMPACTS

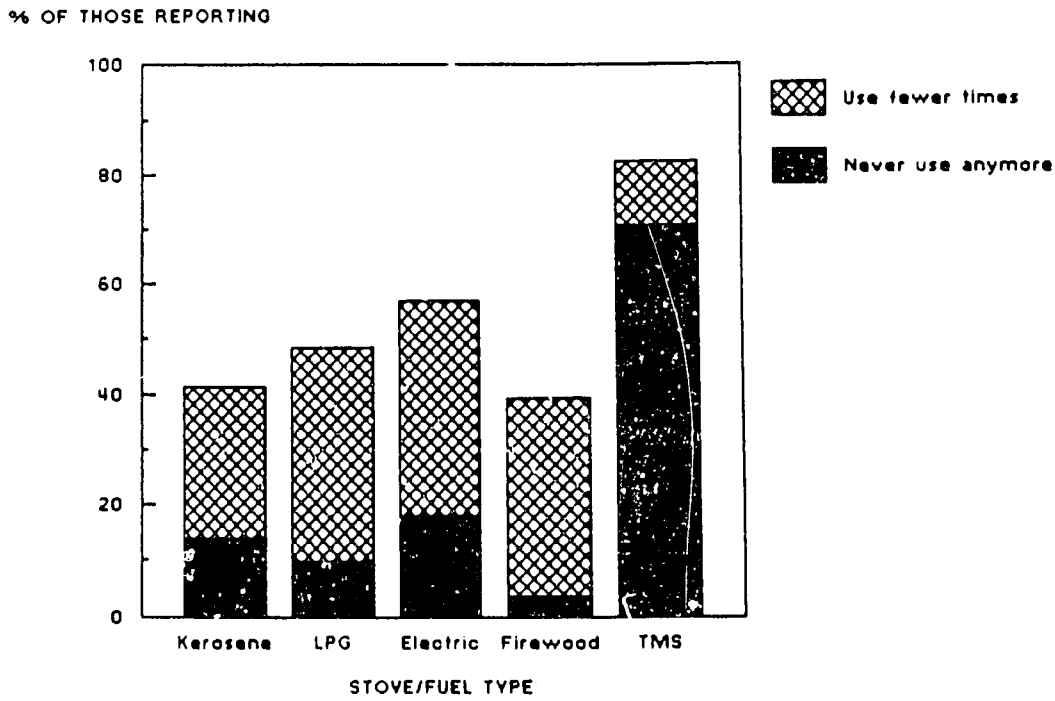
To examine substitution away from kerosene, LPG, and electricity induced by the KCJ in the KCJ Field Test, participants were asked how often they used each type of stove they owned compared to the period before their use of the KCJ. Figure V-5 depicts the

respondents' answers, for those who answered the question (about three-quarters of the sample in each stove category).[19] The figure combines answers from Nairobi and Mombasa.

It can be seen that 41% of former kerosene users, 49% of former LPG users, and 57% of former electricity users indicate some shift away from these former cooking fuels after the advent of the KCJ. Most of this shift is concentrated in reduced usage rather than complete abandonment of the former form of cooking energy. Still substitution into charcoal appears to occur, although no estimates of this substitution effect quantified in kilograms per household are possible at this time. Such shifts would help explain the difference between reported laboratory savings from the KCJ of 30 to 50% and estimated in-home savings of 15 to 40% from the regressions using the 1986 FWD Survey data. While this substitution toward more charcoal cooking indicates reduced charcoal savings over what has previously been reported, such substitution still confers petroleum product and foreign exchange savings. Figure V-5 also indicates that most people gave up their TMS when they began using the KCJ. Fully 70.7% of the respondents indicated completely abandoning the TMS and another 11.6% said they used the TMS less than before.

The KCJ does not appear to have penetrated into commercial use in any substantial way, although no data were available on this use to verify this observation, and therefore no estimates were attempted.

FIGURE V-5
SHIFTS IN STOVE USE AFTER THREE MONTHS OF KCJ USE



[19] The question asked of the respondents included five categories of answers, three of which do not indicate a shift away from other stove use toward greater charcoal use. The two answers used here are that they "never" use the other stove anymore, and that they use it "fewer" times than before.

FUTURE WORK

Future efforts in evaluating charcoal savings and impacts from the KCJ should be concentrated in four areas: improved surveys to estimate charcoal savings in individual households, efforts at quantifying offsetting income and substitution effects, determination of KCJ penetration in the charcoal stove market and consequent national savings of charcoal, and efforts to determine charcoal sources and the impact of conservation on them.

Household Surveys of Charcoal Consumption

Estimates of savings from the KCJ have suffered from inadequacies in household survey sampling design and in the way that questions have been asked about how much charcoal is consumed. Future surveys in this area are important to understand and should include the following components:

1. Stratified random sampling. Samples should be stratified to ensure adequate coverage of different income groups and geographic areas. In Kenya, sample frames from the Central Bureau of Statistics appear to be the appropriate basis for these surveys.

2. Sample size should be determined statistically according to the degree of error desired in the resulting estimates of charcoal use. Enough information exists from prior surveys to estimate the variance in household charcoal consumption and, therefore, sample size.

3. If at all possible, charcoal units should be weighed with a scale in the home, or failing that, at local charcoal vendors' locations.

4. Undertaking intensive field tests which measure charcoal use for several days with the traditional stove and then several days in the same household with the improved stove is the preferred method of determining charcoal savings.

5. Strict criteria for determining income group of each household should be agreed upon and adhered to. Most preferred is getting accurate answers about household income. However, other criteria such as occupation, education, type of dwelling, and quarter of the city as a proxy for income group may be used.

Estimating Income and Substitution Effects of the KCJ

Because the income and substitution effects may offset the technological savings of an improved stove, some observers have called into question the effectiveness of improved stove programs. It would therefore be beneficial to quantify these effects. Gathering the data to do so could be accomplished during the household charcoal consumption surveys--at least to quantify the offsetting effects in the residential sector. What is needed is good information on household incomes, i.e., categorizing households into income groups is not

sufficient. Also needed are accurate prices that households pay for their charcoal, which means not only asking the price paid, but also weighing the units as described in Point 3 of the previous section. Finally, households should preferably be interviewed and charcoal consumption weighed before and after improved stove purchase. From this information, income and price elasticities of charcoal demand could be estimated. Estimating increased amounts of charcoal consumed because of output and substitution effects in the producer sector would require a more general economic model, although a rough idea of such effects can be gained by asking firms about output changes resulting from changes in charcoal price.

Household surveys should also examine the substitution effect by gathering information about the amount of kerosene, LPG, and electricity used before and after the introduction of the improved stove. Reductions in the use of these alternative cooking fuels alongside a less than expected drop in charcoal consumption would indicate the substitution effect. However, all of the difference between the expected and the actual change in charcoal consumption could not be attributed to the substitution effect, since the income effect would be mixed in.

Estimating Market Penetration and National Charcoal Savings

No firm estimate of market penetration has been made for the KCJ since it has become a national product in Kenya. The 1986 FWD Study estimated that the stove had penetrated 17% of the Nairobi market and 3% of the Kisumu market. The validity of these estimates has been questioned due to the limited sample surveyed and the possible lack of representativeness of the sample. To make an adequate assessment of the stove's impact, a careful market penetration estimate is still needed.

Such an estimate would be relatively easy to produce through a wide-reaching, but simple household survey. The questionnaire could be limited to asking type(s) of stoves used and demographic information. If the budget permitted, a few additional questions on charcoal consumption would allow new estimates of charcoal savings, although such a survey would suffer from not actually weighing the amounts of charcoal used. A one-page questionnaire that could serve the purpose of a penetration analysis is contained in Annex 4. Annex 4 also contains a more detailed work plan for conducting such a survey.

With the results of the penetration survey in hand, and an estimate of the amount of charcoal saved, a national charcoal savings estimate would be possible. This would be valuable information in determining the value of the improved stove program, and justifying further investments in the stove's development and proliferation.

Estimating Deforestation Impacts

Finally, supply-side surveys are badly needed as a complement to the demand surveys discussed above. These are needed to determine the source of urban charcoal supply and to permit better estimates to be made of the potential deforestation/environmental benefits from stove programs. The extent of impact of national charcoal savings estimated above on deforestation depends largely upon whether charcoal is coming from areas being cleared for agriculture or from forest felled to supply the charcoal market.

VI. CHOICE OF PRODUCTION TECHNOLOGY FOR IMPROVED STOVES

This section reviews the primary production systems and technology for the KCJ in Kenya. The objectives of this analysis are to evaluate the existing systems in technical and financial terms and then to generalize this review to provide a comparison of systems to assist in replication. Evaluation has included raw material inputs, equipment, facilities, and production methods and scale; relative economics and associated issues, including liner and cladding quality, employment, management requirements, optimum scale for available materials and local markets, and replication issues. The major production technology systems addressed have been characterized as: a) mechanized, b) semi-mechanized, and c) artisanal systems.[1] Analysis has been based on representative producers. Since individual producers may mix techniques that vary in levels of mechanization at different steps in the production process, no completely clear-cut separation of systems is possible.

Various constraints were encountered in the data collection for this analysis. The most serious constraint was the reluctance of some producers to provide complete information and, in some cases, lack of cooperation. This appeared to be due to the relatively mature status of the stove business and competition among producers, as well as the fact that producers are no longer dependent on outside assistance. The information most affected was on production levels and pay scale for workers. In most cases, clear sales records did not appear to be maintained, and other basic business records were hard to obtain. Care was taken to retrieve accurate records, and data were checked with different staff or sources whenever possible. The producers interviewed are estimated to account for over 90% of the ceramic liners for improved stoves produced in the country.

IMPROVED STOVE COMPONENTS

The KCJ has two main components, a **ceramic liner** and a **metal cladding** (covering and frame), which has various subcomponents. Our discussion is separated for the two primary components, as the skill and investment requirements for each are different and not necessarily related. The factors that will influence the expansion of production as well as requirements of capitalization, employment, etc., differ considerably as well.

The production of ceramic liners has been confined primarily to the more formal sector and carried out by entrepreneurs with sufficient funds to set up a production center and hire labor. Metal stoves similar to the KCJ metal cladding have been produced for

[1] This characterization applies primarily to the ceramic liner component of the KCJ.

many years in the form of the traditional metal stove (TMS). Fabricating a cladding for the KCJ therefore was not a difficult task since only alteration of shape and size was required. Where artisanal skills existed, minimal training was required. In contrast, ceramic liner production was more difficult to set up, since clay-working skills are not widespread and skill development is a major undertaking. Currently over 90% of the liner production is carried out by businessmen with medium-scale mechanized or semi-mechanized production units that specialize in liner production. Several informal sector and women's groups have produced liners on a small scale. Claddings, on the other hand, are manufactured primarily in the informal sector by self-employed artisans. Two cases where liner producers also hired artisans to fabricate claddings were identified. The two components are assembled together with an insulation and cement mixture to improve the performance of the stove. This is done by either the liner producer who buys claddings from artisans or vice versa. Assembly is also done by self-employed artisans who buy both the liner and cladding.

Claddings Manufacture. Claddings manufacture has been largely concentrated at Shauri Moyo, an informal sector production center and market in Nairobi. Shauri Moyo is located in the vicinity of the main Nairobi industrial area, which serves as a source of scrap sheet metal and metal rods, the raw material for KCJ claddings and other products. Besides the KCJ claddings, Shauri Moyo metal workers produce the TMS, simple agricultural implements, simple household pots and pans, and tools for tinsmiths. In addition to a reliable supply of raw materials, Shauri Moyo houses a concentration of people with metal-working skills and the specialized tools necessary for KCJ cladding fabrication. As a production center for the TMS for many years, Shauri Moyo was a natural site for KCJ production and sales.

The costs involved in starting up a cladding production unit are minimal. Simple hand tools are used, e.g., hammers, cold chisels, punch, tape, scriber, compass, tinsnips, etc., for a total of about Ksh. 600-800/- a set.[2]

Until early 1987, operations by the artisans were not recognized by the city authorities and no permanent structures were allowed. However, Government policy has now changed toward promotion of the informal sector, and Government has financed improvements in infrastructure for the artisans who are now legally licensed and housed. Approximately 90% of the claddings being used for KCJ production by producers surveyed are made in the Government-financed sheds at Shauri Moyo.

Other major towns where the informal sector is involved in either KCJ or TMS cladding manufacture are Kisumu, Mombasa, and Nakuru. The expansion of cladding fabrication to other urban centers has been largely due to the migration of artisans from the highly competitive Shauri Moyo market to less competitive markets where TMS fabrication was taking place.

Ceramic Liners. Ceramic liner production has been concentrated around Nairobi

[2] US$1.00 = Ksh. 18 (August 1988).

which has been the main market for the improved stoves. Currently, there are six to seven major liner producers in Kenya. Two of the largest liner producers are Jerri/Miaki situated in Kibera, which is a low income suburb of Nairobi, and Waka Ceramics in Tigoni Limuru, some 45 km from Nairobi. In the initial stages of the KREDP, several small-scale liner production units were set up and encouraged in the western part of Kenya, and CARE later supported these units. Assistance to these enterprises was wholly grant-financed. These efforts attempted to build on traditional clay-working skills. Unfortunately, due to many factors, most notably the lack of management, transport, and marketing skills, these units did not perform well and either closed down entirely or produced sporadically and at low rates.

PRODUCTION TECHNOLOGY

Liner production can be divided broadly into four main processes: clay preparation, molding, drying, and firing. Presently, liner production is carried out in three relatively distinct scales or categories of systems. The systems are categorized by both the method and equipment used, which in turn determine the level of capitalization and the scale of production. In this report, these categories are defined as:

1. **mechanized**--machinery is used for most processes in all four stages of production;

2. **semi-mechanized**--where both machinery and hand tools are used for various portions of the process; and

3. **artisanal production**--where the whole process is done by hand and traditional pottery methods are used.

Important factors differentiating these categories and influencing the relative desirability are capital investment requirements, technology sophistication and availability, skill requirements, and management inputs. It is important to note that while mechanization significantly increases productivity per person and consistency in quality, at the firm level semi-mechanized production can operate at similar output levels.

MECHANIZED SYSTEM

The interviews carried out in the preparation of this report showed that only two enterprises are substantially mechanized. Until recently (April-May 1988), these firms produced an average of 300 to 800 liners per week. However, production levels over the last six months have dropped substantially due to various factors, primarily price cutting due to producer competition.

Clay Preparation. Clay is prepared in two stages: pulverization and mixing. The pulverizer installed at Waka Ceramics has a capacity of three tonnes of dry clay per hour, far above the existing expected requirements. Normal utilization does not exceed 30

minutes per week. The pulverizer is engine-driven and has been in operation for seven months.

After pulverization the clay is passed through a pug mill which is driven at low speeds to mix the clay, pottery sand, and possibly other additives into a homogeneous mix. This is important if the clay is to be easily and effectively molded into a uniform, compact liner. The pug mill at Waka is robust and nearly maintenance free. It has a capacity of 450 kg per hour and is driven by a 2.2 kW electric motor. The mill is used intermittently for a total of only approximately four hours per week. This pug mill has been in operation for three years, and maintenance involves only greasing.

Following mixing in the pug mill, the clay is ready for molding. The liners are molded using a so-called "jigger jolly." This is a motor-driven turntable on which a mold is placed and a wedge on a movable arm connected to the frame is used to shape the liner. It takes 50 to 60 seconds to complete one liner. This machine is regarded as the heart of the production system (at Waka Ceramics). Liners made using this machine have a high quality finish, have a very uniform thickness, and are well trimmed. This equipment results in very high production rates per worker. No skilled labor is required to operate the equipment, and two days are the maximum orientation needed for new employees.

The completed liners are dried in a shed on shelves. This allows control of drying rates. The shed is enclosed and utilizes heat radiated from the firing kiln located at one end of the shed. This is especially important during cold/damp weather. An updraft brick kiln is used for firing the liners. This kiln has a capacity of 400-500 liners per charge at Waka and one firing lasts about six hours. The kiln is wood-fired and uses about 0.25 tonnes of wood per charge. The Waka operation requires minimum labor and only two people are required to produce about 150 liners per day, inclusive of firing time. Very little supervision is required. Figures VI-1 and VI-2 show the major items of production equipment of the mechanized system.[3]

At Jerri International, clay is pulverized manually and a pug mill is used for mixing. There are a number of important differences in this mill compared to the one at Waka. It has a capacity of only 40 kg of clay compared to 450 kg at Waka. The mill can only produce enough material for 80 liners per 8-hour shift working at full capacity. Even this is not normally achievable. Therefore, the capacity of the pug mill is considered a major bottleneck that would prevent expanded production unless foot mixing is employed as well. This mill is more than five years old.

Jerri International also had a "jigger jolly" fabricated, using the jolly at Waka Ceramics as a model. The results, however, were not as satisfactory. The jolly is still at this site although it is not used. Liner producers at Jerri are skilled potters and prefer using

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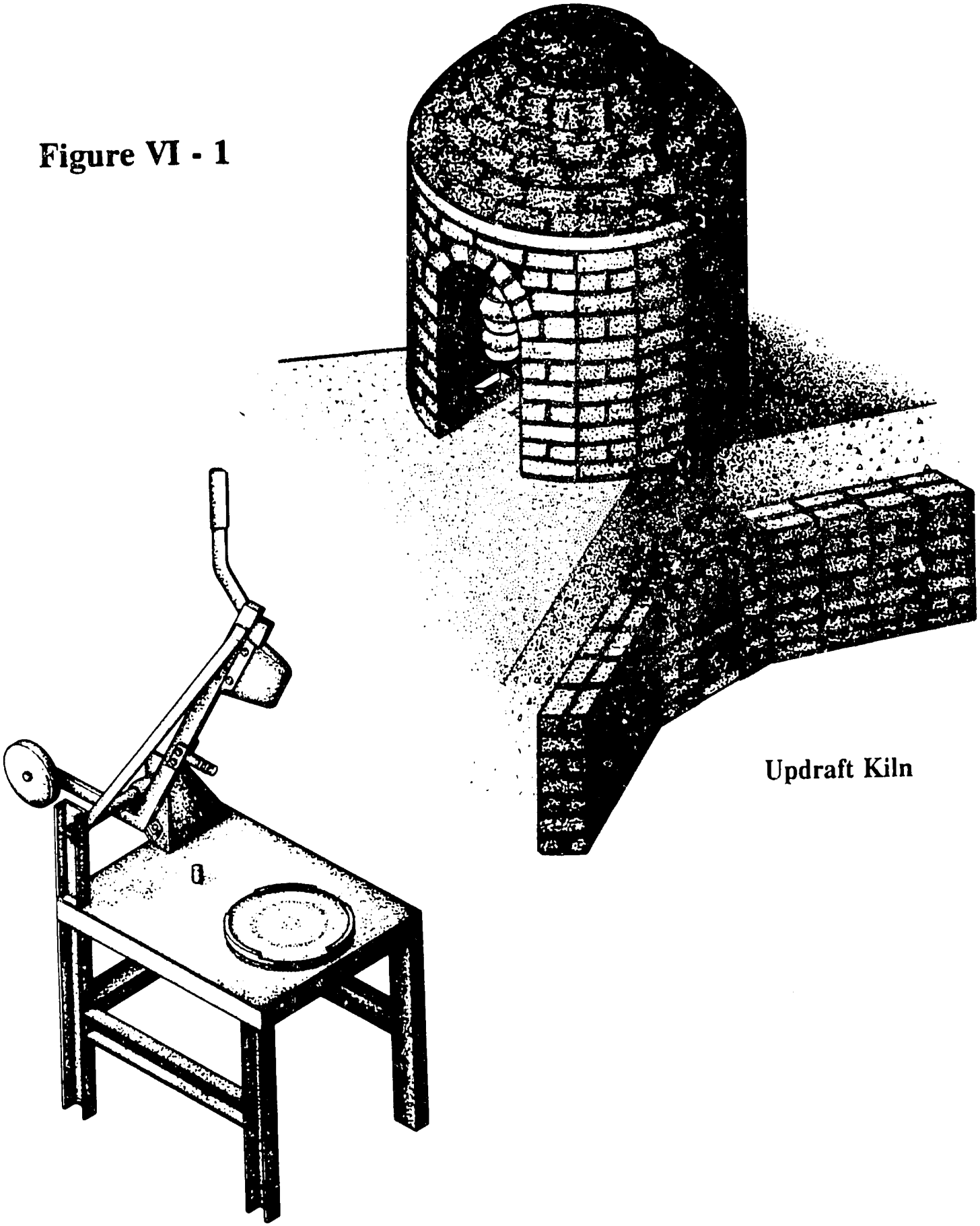
[3] Based on equipment developed and presented in Hugh Allen, The Technology of Ceramic-Lined Charcoal Stoves Mechanized Production in Kenya (CARE International, April 1988).

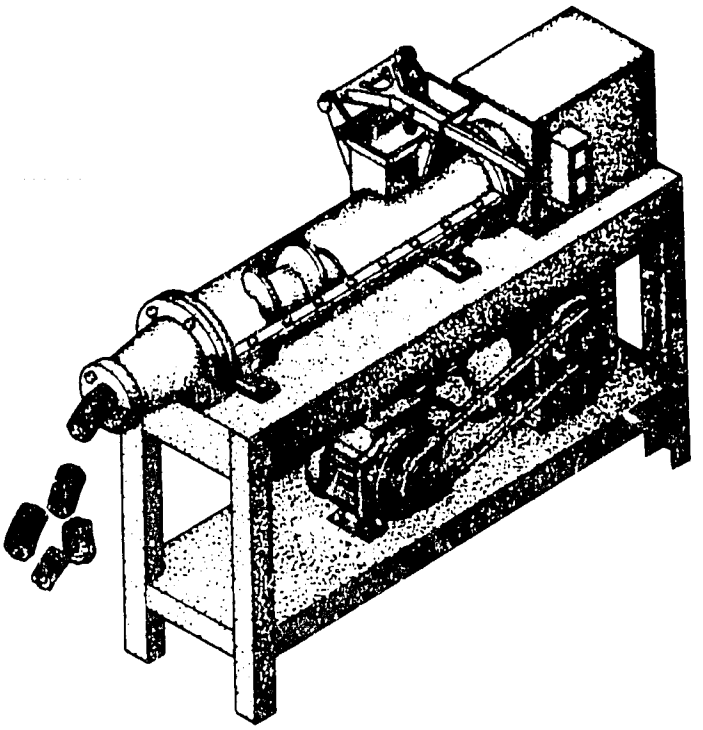
Figure VI - 1



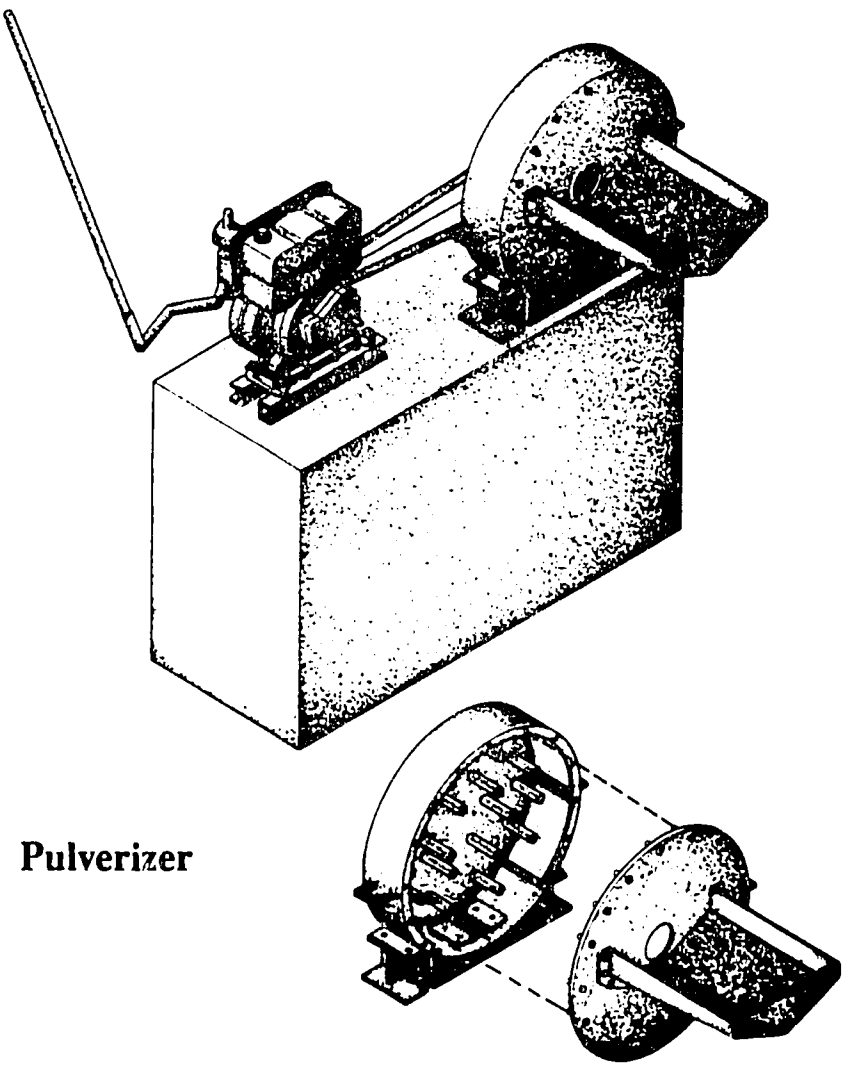
Updraft Kiln

Electrical Molding Unit
"Jigger Jolly"
(Shown without liner mold)

Figure VI - 2



Pug Mill



Pulverizer

an electric throwing wheel for molding. The throwing wheel can only be used by experienced potters who develop a "measuring rule" on their hands since no molds are used.

With the throwing wheel, the three potters at Jerri can produce a liner in two minutes, but total production per day hardly exceeds 50 per person per day because the prepared clay available is insufficient. This clay is prepared by other workers. An electric kiln is used for firing the liners. This kiln has a rating of 35.5 kW and a maximum temperature of 1300° C. Liners are fired at 700° C. The kiln is easy to charge and operation temperature is easy to control, allowing the liners to be uniformly fired. The reject rate from the firing is roughly 1%. The kiln takes about 60 liners per charge, with firing time averaging 5.5 hours. Higher costs for electrical as opposed to wood-firing have led to a reduced production rate.

SEMI-MECHANIZED SYSTEM

Approximately 75-80% of the total liner production in Kenya, is accounted for by producers in this category. These producers include: a) Sunrise Clayworks, b) Jiko Bora (Miaki - Liners), c) Jerri/Miaki, and d) Rural Enterprises (RURALTEC). The level of equipment used varies across enterprises, but generally many aspects of production are similar. A significant factor negatively affecting the more labor intensive producers is the mobility of workers who move frequently from one producer to another. Causes of this movement are primarily the presence of major differences in labor arrangements and wage rates.

Typically, all clay preparation is done using hand tools, hoes, and shovels. This is a slow and tedious process requiring three man-days to mix clay for 100 liners. Molding is done using hand-rotated potter's wheels with an outer mold to hold the clay as the inside of the liner is fashioned by hand. The molding process using this technique allows a skilled worker to produce a maximum of 30 liners per day. The potter's wheels are made from a car tire rim with a ball bearing mounted horizontally on a steel-rod spindle. The wheels are made locally for Ksh. 2,500/- to Ksh. 3,000/- each. Liners are fired using either earth pit kilns or simple brick kilns.

The semi-mechanized system requires much less capital and is much more labor-intensive compared with the mechanized system. The enterprises cited availability of skilled labor for molding and supervisory work as major constraints in expanding production. A production of 100 liners a day requires a constant labor input of six to eight workers for clay preparation, molding, finishing and supervision.

ARTISANAL SYSTEM

This system is confined to Western Kenya where pottery skills have been passed on over many generations. The process of clay preparation is similar to the semi-mechanized system. Molding, however, is done solely by hand. This system has a very low rate of production. Current activities are carried out by women's groups, which produce pottery in parallel with their domestic duties; thus, production rates are not consistent. Each

worker produces 20-25 liners per day when working full-time. The groups have fluctuating liner production rates with two main groups--Keyo Women's Group and Nyasanga Women's Group--producing a total of 200 liners per month. No private entrepreneur is involved in this part of the KCJ liner production system; rather, the two main groups are cooperatives.

STOVE ASSEMBLY

Assembly is a simple job and one fundi (artisan) can assemble and paint 20 stoves per day. The liners and claddings are transported by bus and mutatu to assembly sites, as well as markets. For a distance of about 40-50 km, the transport cost is about Ksh. 1/- per stove. Inputs for assembly such as vermiculite and cement are readily available in the Nairobi area. However, vermiculite is not readily available elsewhere. Liners and claddings are assembled in three ways:

1. Assembly by liner producers

Presently, only two liner producers are substantially involved in assembly. Jerri International purchases claddings from Shauri Moyo and assembles stoves. Sunrise Clayworks fabricates claddings from metal collected from the owner's farm, produces liners from clay on the property, and assembles complete jikos from these parts. Waste metal stocks are available to last two years at a rate of 2,500 claddings per month. Sunrise employs ten artisans working full-time for all operations. This enterprise has been in operation only since June 1988.

2. Assembly by cladding manufacturers

Liner producers sell most of their production to cladding manufacturers and assemblers. The cladding manufacturers work full-time on stoves and assemble at their place of operation and sell to both individual customers, wholesale distributors, and retailers. Quality control has been a problem with this group since they typically sell without receipts and seldom are available (can be found) if customers encounter a problem with the stove.

3. Assembly by entrepreneurs who buy claddings and liners and resell at retail

Ngwathi Associates in Thika, Ruiru Jiko Workshop, and Ilesi Pottery fall under this category. The first two operate within smaller towns and are very conscious of the quality of their products. Prices also tend to be 10-20% higher than in Nairobi. Orders for claddings are placed with individual artisans who make claddings, using dimensions specified by assemblers. These assembly and sales enterprises have lower profit margins than producers but turn out good quality stoves. However, their markets are subject to competition from major producers of stoves from Nairobi which may involve severe undercutting of their prices.

CURRENT KCJ PRODUCTION

In several of the reports written over the last three years on stove production, it appears that there has been as overestimate of the number of stoves produced due to double counting of claddings and ceramic liners.[4] In order to provide a more accurate picture of stove output, a review of production levels was included in the analysis of production systems for this report. Based on this limited review, it is estimated that current KCJ production is between 125,000 and 140,000 per year. This estimate is based on production reported by liner producers in personal interviews, and verified where possible, by alternative sources, such as, claddings purchases and equipment capacity. An attempt was also made in conducting this analysis to document cumulative stove production to date but this proved infeasible. In some cases, producers do not maintain adequate sales records; and in other cases where records existed, they were not made available.

Production of liners in the country is very dynamic. This can be attributed to a number of factors, including both fierce price competition and temporary problems in stove liner quality, resulting in loss of markets, among other factors. Prices of liners to artisans assembling an estimated 80% of total stoves have been cut by about 30% over the last six months (December 1987-May 1988). This was the result of fierce price competition among the major liner producers, rather than by other forces such as cost savings or volume production. This has resulted in significant losses for some producers, who subsequently reduced liner production to concentrate on other pottery products. Prices for the KCJ dropped from Ksh. 60/- to Ksh. 70/- for the 10 inch size sold by liner producers manufacturing assembled stoves. Ceramic liner price alone when sold separately by producers fell by Ksh. 4/-.

PRODUCTION SYSTEMS COMPARISON

The comparison of production technology below, reviews the financial returns and other characteristics of ceramic liner production systems. All rates of return presented are rates of return to equity (the non-financed part of investment, that is, the owners share), which is assumed to be 100% of investment in all cases presented. As indicated below, investment by current producers in Kenya is virtually all owner's equity. The review focuses on mechanized and semi-mechanized liner production systems only. Liner production in Kenya is concentrated in these two systems, while artisanal production has not proven to be sufficiently viable for it to reach significant production levels, nor for it to be offered as a replicable system. Metal cladding production systems are not included in this financial analysis since in all systems but one, costs and sources are basically the

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[4] Monica Opole, The Kenyan Improved Stove Program (Nairobi: Energy Development International, 1985); Eric Hyman, Decentralized Production and Distribution of an Appropriate Technology for a Consumer Durable: The Kenya Charcoal Stoves Experience (Washington, D.C.: ATI, 1985); and Monica Opole, The Introduction of the Kenya Jiko Stove (Nairobi: KENGO, April 1987).

same. Metal cladding production and economics have been dealt with previously by various authors.[5]

Several outcomes of financial analysis of ceramic liner production should be noted at the outset due to their importance. First, financial returns are very sensitive to production and sales levels. Profitability is greatly influenced by the level of capacity utilization which, in turn, can be significantly affected by competition. This sensitivity is particularly great with higher levels of capital invested. *Given this sensitivity, purely commercial entry and investment in this business would be expected to be less capital-intensive and smaller in scale than if promoted by external (donor) assistance. Greater capital intensity and optimal investment levels in solely commercial systems (from a cost and technical efficiency standpoint) would be expected only to follow as growth occurs in the market and market share increases. Furthermore, production levels between 1,000 to 2,000 units per month appear to be the minimum level for mechanized or semi-mechanized systems to earn a positive return. This outcome is the result of the significant cost of basic infrastructure such as buildings and production equipment, and the financial (or opportunity cost) of land.*

Second, *the initial production efforts of all producers surveyed showed that substantial start-up investment was sunk into the development phase of each enterprise; that is, primarily into, a) identification of clay sources, clay mixing and testing; and b) the design and construction and rebuilding of kilns. In making financial comparisons of production technology here, investment estimates were based only on the final plant and equipment eventually installed, which can significantly understate the actual costs of establishment.* Unfortunately, data availability permits neither an estimate of start-up costs for past production units, nor an estimate of the extent to which these types of costs will impact future producers. It is concluded however, that due to such start-up costs, higher rates of return would be required to induce new producers to enter the improved stove market, versus returns expected in an industry with more mature technology.

Third, *the entrepreneurs' own time in establishing a production unit, organizing cladding component production and assembly, and developing markets is not costed in this financial analysis.* It is assumed that this time is compensated for by the total return on the entrepreneurs' equity. Thus the financial analysis represents the total return to both the entrepreneurs' capital and the substantial initial time invested in the enterprise.

Fourth, *ceramic liner loss (reject) rates within the production system itself were found to differ significantly between production systems and to have a substantial impact on financial returns. The mechanized system was noted to have experienced much lower loss rates, roughly one-quarter those of the semi-mechanized systems.* Rejection rates are affected by a number of factors, including clay mixing and molding problems, handling and drying, and kiln firing. However, this does come at a cost of significantly greater capital investment.

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[5] Maxwell Kinyanjui and Arsen Mbonye, An Informal Survey of the Cookstove Industry: A Case Study of Shauri Moyo, KREDP (Energy/Development International, 1983); Simon Burne, Charcoal Stove Development in Kenya (Intermediate Technology Development Group, 1985).

LINER PRODUCTION SYSTEM CHARACTERISTICS

The overall production and financial analysis of production systems is summarized in Table VI-1. Shown are 2 cases of mechanized production systems and 3 cases of semi-mechanized systems, to provide a range of characteristics from actual experience. The table presents basically five categories of information. First, production and capital cost are shown along with recent estimated production levels. Second, labor intensity is presented in terms of labor and management requirements for each of the cases. Third, total variable costs are presented (variable cost components, that is, labor, management and other costs are shown in Figure VI-4). Fourth, quality and uniformity of production is depicted through combined loss or reject rates from all causes. And finally, estimated rates of return to investment are presented for each of the cases.

Table VI-1
CERAMIC LINER PRODUCTION SYSTEMS CHARACTERISTICS

UNIT TYPE	MONTHLY PRODUCTION (3)	INSTALLED CAPACITY (4)	CAPITAL INVESTMENT (all figures include estimated land costs) (1) (Kshs.)	CAPACITY UTILIZATION	REGULAR STAFF	MANAGEMENT TIME (equivalant days/week)	TOTAL VARIABLE COST/1000 LINERS (Kshs.) (5)	LOSS OR REJECT RATES (6)	ASSUMED SALE PRICE/LINER (Kshs.)	RATES OF RETURN ON EQUITY (Assumed 100% equity financed (7)
Mechanized System (average)										
Case 1 ·	1,800	4,000	278,000	45.0%	2	1	8.3	5.0%	14	30.0%
Case 2 ·	3,200	10,000	336,000	32.0%	3	2	7.4	5.0%	14	65.0%
Semi-Mechanized System										
Case 1 ·	2,200	2,600	138,600	84.6%	10	6	10.7	20.0%	14	42.0%
Case 2 ·	5,000	8,000	194,250	62.5%	17	10	10 · 12 (estimated)	20.0% (estimated)	14	63.0%
Case 3 ·	500 (to 1,000)	1,100	100,000 (2)	45.5%	5	3	8 · 11 (estimated)	35.0%	14	Negative 7.4%

1. Land is assumed to be Ksh. 75,000/· in each case except as otherwise noted.
2. In this case only, land is assumed to be Ksh. 37,500/·.
3. Production figures represent output levels at the time the producer survey was undertaken, April-June 1988.
4. Production capacity for semi-mechanized producers is dependent on both labor and site and other facilities. Figures are for an 8 hour day in existing facilities assuming labor is not constrained.
5. Variable cost excludes any allowance for capital recovery; it includes Ksh. 1/· for transport and Ksh. 1/· for marketing, respectively.
6. Rough estimates of total losses of molded liners due to all factors, including drying, handling, firing or other.
7. Excludes consideration of taxes.

While the discussion of production issues below is not exhaustive, it is sufficiently detailed to alert those attempting to promote or establish an improved stove production unit, to the central issues to be considered in the choice of technology and level of investment. It is obvious from Table VI-1 that there are major differences in the capital cost, labor inputs, and loss rates for the different systems. However, due to the multitude of variables which go into the choice of production systems, it is infeasible, except on a case by case basis, to determine the "best" production system. Many factors combine to affect the producers rate of success, and some of the more important are discussed below. For example, the capability and willingness of the entrepreneur to directly manage a new stove enterprise, while important for all systems, is much more critical for the more labor intensive semi-mechanized systems. On the other hand, the availability of capital and the ability to withstand the risk of loss associated with capital investment is a prerequisite to the choice of a mechanized system. Other key considerations related to the choice of production technology, but equally important to the size of the system, its location and organization; include the estimated market size, the availability of clay deposits in the vicinity, availability of skills in ceramics and metal working, and the cost and availability of land and other inputs, among others.

Capital Intensity

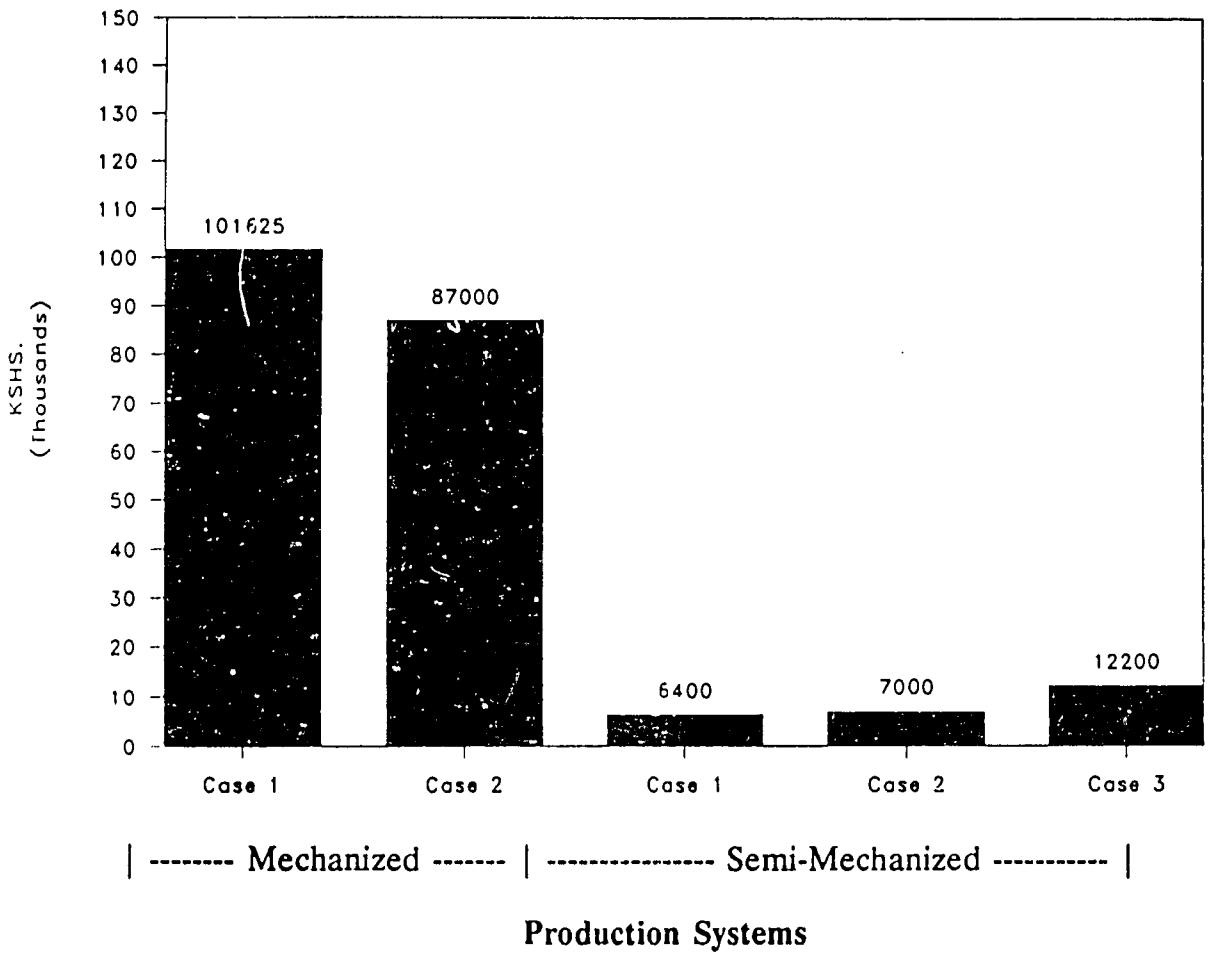
Mechanized production cases exhibit the highest initial investment, ranging from about Ksh. 203,250/- to 260,000/- (excluding land), for maximum output capability of about 4,000 - 10,000 units per month, respectively. Maximum output capacity it should be noted, is somewhat difficult to determine in practice, since additional labor, longer shifts and varying individual equipment capacity affect maximum capacity. Capital investment cost per unit produced represents a measure of the capital intensity of production, and since it includes actual production levels achieved, indicates the degree of realized capital utilization and capital cost. Comparing capital cost of production (excluding land) for mechanized production in case 1, at an output of 20,520 units per annum (1710 per month), capital investment is Ksh. 9,900 per 1,000 units annual production. For case 2, at output of 36,480 per annum (3,040 per month), capital investment is Ksh. 7,155/- per 1000 units annual production.

Semi-mechanized systems make-up both the largest number and greatest installed capacity in Kenya today. Capital costs for these systems vary between a low of about Ksh. 60,000/- to a high of Ksh. 120,000/- excluding land. The major fraction of this cost is for the building which houses the production unit, with production-related equipment and the kiln making up roughly 30%. The relative capital cost per unit output varies with the intensity of utilization which differed significantly between the units observed. The costs for the mechanized system range from about four to five times greater than the capital cost per unit output of the two largest of the semi-mechanized units (see Table VI-1).

Financial Returns

As the comparison above helps to demonstrate, the financial returns of a mechanized producer will vary significantly both by capital investment level and output level.[6] One item of equipment was found to be particularly significant for the systems reviewed, this was the pulverizer. Although it represents about the same level of investment as the "jigger jolly", about Ksh. 30,000/-, it is operated at very low capacity utilization rates. Downsizing this piece of equipment, thereby reducing its cost, significantly raises total returns. In the lower output case (1800 units), a modest rate of return[7] of 19% was earned on the complete mechanized package, with returns rising to 30% when the clay pulverizer was assumed to be downsized, thereby cutting its cost by one-half. Rate of return rises to 45% when the

FIGURE VI-3
CAPITAL INVESTMENT PER EMPLOYEE



[6] All current production units in Kenya appear to have been financed almost 100% from owners' and partners' own funds. The analysis in this section, therefore, has assumed that equity is 100%, except where otherwise noted in sensitivity analysis.

[7] All returns are before taxes.

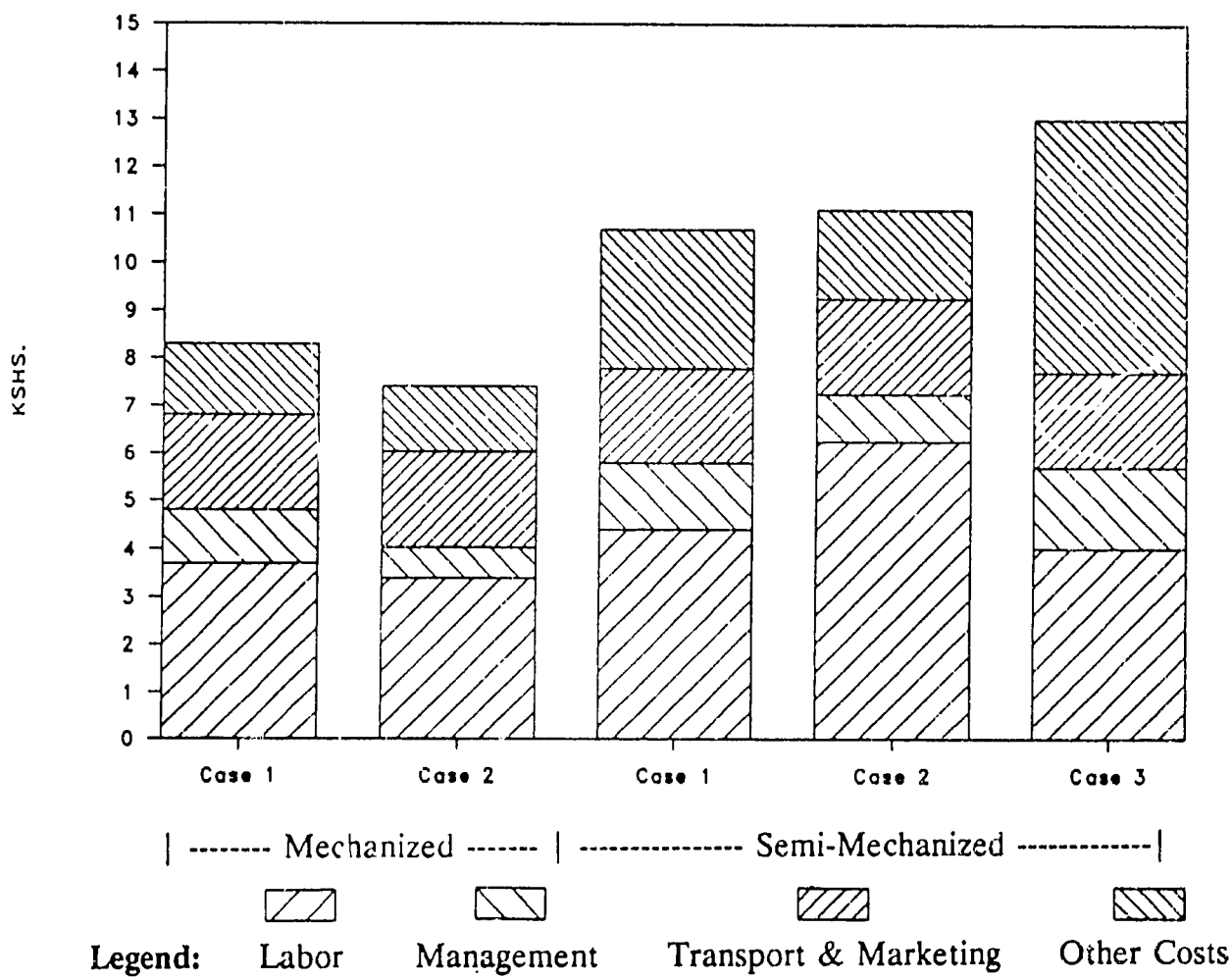
pulverizer is completely eliminated. Unfortunately, due to the unavailability of data, no proper adjustment was possible for the expected minor additional costs of labor to compensate for the elimination of the pulverizer, nor for somewhat higher liner loss rates without the pulverizer. Sensitivity analysis indicated that a 25% increase in labor cost combined with a 25% increase in loss rates, produced a 30% decrease in total returns, significantly lowering the advantage of eliminating the pulverizer (for these hypothetical assumptions).

Semi-mechanized systems were found to produce very attractive returns at fairly high production levels, for example, 63% and 85% in two cases. Rates of return range from about 40-60% for two major producers, with a third producer in this category apparently earning negative returns due to inadequate current production levels (capacity utilization about 45%). The mechanized production units produced similar rates of return at equivalent levels of output.

Labor Requirements and Related Issues

Figure VI-3 above provides the relative investment per employee for the different mechanized and semi-mechanized production cases. Investment per employee ranges from a high of Ksh 87,000/- to Ksh. 101,625/- for the two mechanized system cases, and decreases to Ksh. 6,400/- to Ksh. 12,200/ for three semi-mechanized production cases.

FIGURE VI-4
VARIABLE COSTS FOR DIFFERENT SYSTEMS



The mechanized production system exhibits the most modest labor requirements of any of the systems, with the cost of labor running about Ksh. 3.7/- per unit produced, or about 40% of variable cost (excluding any capital recovery). Management costs, even with rates of compensation assumed to be about five times greater than for other systems (due to both greater skills required and the producer's labor compensation policy), account for only about 12% of variable cost. It should be noted that a constant amount of Ksh. 1/-, was assumed to be the variable cost for both marketing and transport, respectively. These figures are consistent with reported values, and although inexact, improve the realism of the total variable costs, and the rates return derived in this report. Total variable cost shown in Figure VI-4 for mechanized production cases, ranges from about Ksh. 7.4/- to Ksh. 8.3/- per unit.

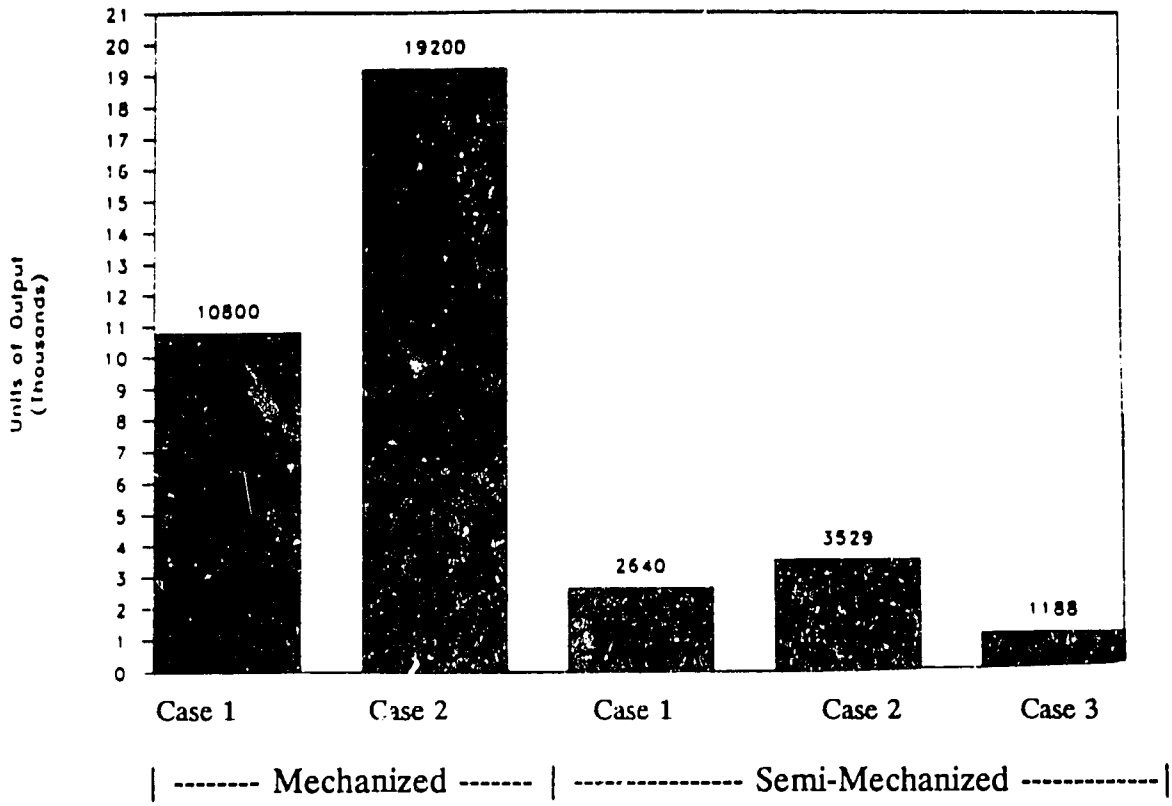
The two largest semi-mechanized producers (Case 1 and 2, respectively), employed about 10 and 17 employees, with labor comprising about 40% and 60% of variable cost, and total variable costs of about Ksh. 11/- (Figure VI-4). Semi-mechanized system labor cost ranged from about 20-50% greater than the mechanized unit. Variable cost differences tended to be dominated by the cost of labor. For comparison, only two to three staff were employed by mechanized producers, although these staff were more highly compensated.

In interviews of producers conducted for this report, producers emphasized that labor was a major production problem, both in terms of basic supervision required, and in terms of training requirements and total cost. The mechanized production units were substantially less troubled by labor problems and required less training to produce a fully qualified laborer. Work was also considerably less difficult physically in the mechanized system. While the mechanized system provides less employment, it is much more easily managed and, therefore, is likely to be considerably more attractive where management time is scarce. Given the substantial management effort required in a new stove enterprise, for example, for market development and distribution, it would appear that the mechanized system would tend to be very attractive, if required capital is available.

Semi-mechanized producers appear able to respond within a fairly wide range, to both short and long-term changing output levels, given their ability to lay-off labor. Frequent changes, however, could be very disruptive to this system, as hiring new labor and associated training would be required. The small labor force of the mechanized producer makes retaining labor during a temporary market decline less costly. There is, however, greater financial risk for the mechanized producer in a volatile market due to his higher fixed cost of capital.

In order to obtain a sense of output in relationship to labor input, Figure VI-5 (on the next page) was prepared. The figure shows annual production per regular employee for the production systems surveyed, which ranges from highs of between 10,800 to 19,200 units for the mechanized systems, to between 1,188 to 3,529 units for semi-mechanized systems.

FIGURE VI-5
ANNUAL PRODUCTION PER EMPLOYEE



Financing for Investments

Sensitivity analysis was performed to determine the impact of introducing partial financing of investments in all production systems. It was observed in our review of producer finances, that given the type of business and its relative newness, even in Kenya where it is relatively mature, external financing from commercial sources has been almost non-existent. The introduction of partial outside financing in our analysis produced a major improvement in returns to the producer due to the impact of leveraging the producers investment. Returns increased in the mechanized high output case by almost 100%, and in the low output case by 20% (with equity at 30% of total cost, and financing at 15% annual rate of interest). Similar impacts were observed in semi-mechanized systems. *Given the relatively high risk of new investment in an improved stove enterprise, and the relatively high cost of mechanized production for a small-scale manufacturer, investment credit could be extremely useful in raising profitability and inducing additional production. An important caveat to this conclusion, however, is that for a relatively more risky investment of this type, a financing package needs to be structured to compensate for these higher uncertainties. Strictly commercial financing, except for the expansion of established producers, is unlikely to produce a strong inducement to additional production, or to optimal production systems in an economic or technical efficiency sense.*

VII. ASSESSMENT OF THE KENYA IMPROVED STOVE EXPERIENCE

The assessment of the Kenya stove experience below reviews the major components of the program and program status and outlines lessons learned. The degree of success of the Kenya Ceramic Jiko (KCJ) development and dissemination are evaluated in terms of performance in the field, program sustainability, energy savings, and financial benefits achieved. In summary, a successful improved stove program is considered one in which the user prefers and buys the stove introduced, producers find the stove technically feasible and profitable to produce, the retailer finds it sufficiently attractive to devote "shelf space" to its retail sale, and finally, the donor and the Government counterparts satisfy their institutional, social, and energy savings objectives.[1]

SUMMARY

FINDINGS

The Kenya stove program can be judged a success based on the criteria applied in this report. The following were found:

1. Users have generally found the KCJ to save fuel and reduce their energy expenses; they are satisfied with the stove's performance and durability and are readily buying stoves where available through normal commercial channels. Estimated sales of up to 140,000 per year demonstrates consumer acceptability.

2. Producers have found the KCJ profitable to produce and sell. The technology has matured sufficiently for stoves to be produced in large numbers and to be of acceptable quality in most cases.

3. Retailers and informal sector assemblers of the KCJ have become heavily involved in commercial sales, even to the extent that the country's major artisan market, Shauri Moyo, displays and sells a majority of the KCJ. Competition has significantly lowered prices in Nairobi and quality appears adequate, based on general customer satisfaction.

4. Government official support for the program has reflected satisfaction with the technical performance, as well as beneficial employment and income enhancement impacts of the KCJ. A.I.D. has basically satisfied both its energy conservation and dissemination objectives for the KCJ program. The program

[1] These criteria are consistent with the FAO Guidelines for the Monitoring of Pilot Stove Development Schemes (Rome: FAO, 1985).

is self-sustaining and growing moderately.

REMAINING ISSUES:

1. Availability outside Nairobi still remains inadequate, and prices are too high for many potential consumers. Consumer knowledge of how to judge quality and how to use the KCJ is still not sufficient, and the general promotion and publicity of the KCJ requires expansion.

2. Dissemination of stove production technology is impeded by inadequate information on the technology. Private sector and Government technical assistance in stove production is still very limited and needs expansion.

3. Overall distribution and, therefore, availability to retailers is insufficient outside Nairobi. Distribution and availability to retailers needs to be improved, for example, by more dispersed and regional production of stoves.

4. Government budgetary support for stove activities has been decreased substantially over the past few years, and Government's role in public information and monitoring and evaluation requires renewed commitment. In retrospect, A.I.D.'s withdrawal from the project was premature and detrimental to technology refinement and monitoring and evaluation.

CONCLUSIONS:

The significant observed average charcoal savings (17-50%) and rapidly realized financial benefits of the KCJ users are persuasive arguments in terming the Kenya Ceramic Stove program a success. Real and substantial reductions in urban charcoal consumption can also be expected to contribute to a slowing of the rate of tree cutting for charcoal production when this cutting is due to urban charcoal supply. Nonetheless, as is shown in this section, this experience in developing and disseminating the stove has been far from perfect, and many remaining issues still need to be resolved if the KCJ is to rapidly and effectively reach the large prospective market. Savings of Ksh. 350/- in annual costs for a low income urban family, equivalent to 1/2 of one month's average wage, forms a powerful argument for continuing support by the Kenyan Government, donors, and other interested parties (e.g., NGOs).

There is the impression in reviewing the Kenya stove experience, however, that the Government and the donor community have lost interest in the charcoal stoves program. Fortunately, private commercial production and sales are still expanding, and small-scale promotion and technical assistance activities by NGOs and the KU-ATC are continuing. These activities alone, however, are not sufficient to stimulate a significant expansion in stove sales except in the medium to long-term, and near-term deficiencies are likely to remain unresolved. The Government, for its part, appears to have lost its strong

initial commitment in this area and has diminished both its funding for MOE stove activity and policy level support.

The following recommendations are intended to provide guidance on the specific support that is needed.

RECOMMENDATIONS

There are a multitude of gaps identified in this report which merit priority attention both by the Government and by the donor community. While it is true that substantial private sector activity exists in improved charcoal stove production, both the remaining market potential and unrealized social benefits are very great. The review in this report has identified several major areas where remedial action and further Government and/or donor support to the KCJ program is warranted. These include the following:

1. **Government Policy**

a. A more activist approach by Government agencies at the national and district levels in the improved stoves area could be very beneficial. For example, the Government could get behind the dissemination of the KCJ via a *broad promotional effort,* involving use of appropriate media (e.g., radio, Harambee publicity, and circulation of written educational materials), and high level visible Government support.

Many persons interviewed expressed misgivings concerning the future of the improved stoves program in Kenya if it were to substantially involve or rely on the Government. An analysis of this program, however, indicates that a conscientious input from Government could be helpful in a number of areas including public information, program monitoring, and, potentially, in surveys of sales and stove penetration. Ultimately the Government's contribution and role in this program will be determined by its commitment of staff, budget, and policy support.

2. **Monitoring and Evaluation**

At present, there is no systematic collection of data on either the production or penetration of improved stoves in Kenya, or on the identification of production or dissemination problems. At a minimum, the following monitoring and evaluation tasks should be undertaken:

a. Sales patterns and stove prices should be monitored via periodic survey in major markets.

Potential questions to be addressed include: How many KCJ's are being sold in Nairobi? Is this number growing or declining? What steps are needed to make the KCJ more accessible to the low-income household? For example, is price the major constraint and is credit needed? To what extent are sales limited due to the centralization of sales in Shauri Moyo in Nairobi? Are KCJs available outside Nairobi, why or why not?

b. Stove penetration, consumer use, and stove quality surveys should be periodically conducted.

Potential questions to be addressed include: What fraction of households have purchased the KCJ relative to the traditional stove? How durable is the KCJ? What levels of savings are being achieved? What other benefits are being received? Fewer burns by children, faster cooking, etc.? Are the families using charcoal for more of their cooking after adopting the KCJ? What problems have the households encountered in the use of the stove; for example, availability of parts and repair service? Do the households know how to use and care for the stoves properly? Do the households have suggestions for improvement in the stove?

c. Fuel price data base improvements are needed.

Fuel price data for household energy planning is deficient, and various problems need to be remedied to provide a sound basis for improved stove policy and other household energy related decisions. The following are particularly needed:

Charcoal prices. The regular field surveys of prices by the Central Bureau of Statistics (CBS) need to be modified to provide for the weighing of charcoal and the discontinuation of the use of gazetted prices rather than actual market prices. Furthermore, price data should be gathered seasonally to capture and isolate the effects of seasonal price variation.

Paraffin (kerosene). CBS' regular surveys of paraffin price should discontinue the practice of recording official service station pump prices as estimates of market prices. The normal mode of purchase of paraffin by consumers is in small resale quantities, and observed differences in pump and resale prices to consumers in small retail outlets are substantial (e.g., in some cases 75% greater than pump prices).

3. **Program Expansion and Improvement**

Further program support is warranted, given both the energy savings and disposable income enhancement associated with the purchase and use of the KCJ. The means by which to promote further expansion of KCJ production are as follows:

a. Public information and general promotion require expansion.

A program is needed for informing the consumer on how to choose a quality improved stove and how to use the stove. In addition, support for promotion via the media, demonstrations, general publicity, and finance or credit programs is needed. This additional effort could be undertaken at both the national and district level by Government, as well as by interested NGOs. The closer the implementing entity is to the ultimate consumer, the more effective this type of activity is likely to be.

b. Technical assistance is needed in stove production technology.

Expansion of the market for the KCJ will require more stoves to be produced, which in turn will require expanded distribution and production. At this time, however, there is no adequate facility in the country for providing technical support to parties interested in KCJ production. Lack of standardization of production technology and the transfer of out-of-date or inappropriate technology remain problems. Government Agroforestry-Energy Centres, for example, are several years behind the private sector in equipment and ceramics experience. NGOs and the KU-ATC lack adequate numbers of professional staff, and current staff need more experience in stove manufacture. There are generally inadequate numbers of professional personnel nationally available to assist new KCJ business in, for example, clay selection and mixture, production equipment design and operation, kiln construction and operation, and basic business advice on marketing.

c. Testing and development programs require funding.

No adequately funded stove testing program exists in Kenya today, although capability has been developed at the KU-ATC. Such a testing program would involve: a) tests of efficiency in the laboratory and under actual cooking conditions; b) capability in materials selection and analysis, stove design improvement, and new stove development; c) improvement in production methods; and d) establishment of minimum quality guidelines. Funds for such testing at KU-ATC are now limited to normal operating funds and minor donor support. Need for the above capabilities is regional (throughout East and Southern Africa), and consideration should be given to the establishment of a specialized regional capability to service such needs located in appropriately selected institutions, existing programs, or organizations. (See recommendations in Section VIII)

d. Training programs need expansion and evaluation.

The scope of training at Government Agroforestry Energy Centres needs to be reevaluated, and training needs to be upgraded. Objectives for Centre-based training should be formalized. Current training of small artisans in clay liner manufacture and firing and in metal cladding manufacture is much too limited to impart all of the necessary skills. Trainees are also not selected at a high enough level of capability to ensure that the skills being taught can be learned and applied. It is unclear whether or not Centre-based artisan training, even if it were to be improved, would be productive without entrepreneur identification beforehand and sufficient financial, marketing, and technical support to ensure that a viable small-business ultimately results.

e. Credit expansion is desirable.

Expansion of the KCJ program, particularly outside Nairobi, requires additional finance. Lack of adequate credit has been consistently identified as a problem by existing and prospective producers. Credit support must be designed to reflect both the small-scale and risky nature of this business. The Rural Enterprise Program sponsored by A.I.D. may be one appropriate vehicle for such credit, and the MOE's own Energy Development Fund,

now gazetted, should be utilized for this purpose. Experience shows, however, that the prospective producer should not receive a "free-ride," but should expect to pay commercial rates for credit and contribute his own time and effort. In return, he should receive sound technical help through the program.

PROGRAM ASSESSMENT

TECHNOLOGY SELECTION AND EVALUATION

The initial criteria for the selection of improved stoves for further development and dissemination in the KREDP was based on a set of pragmatic technical, economic, and social criteria (see Section IV). *The significance of these stove selection criteria cannot be stressed too much because adherence to them helped ensure consumer acceptance, profitability for producers, fuel savings in actual household use, and consistency with Government policy regarding informal sector involvement.*

Early assistance from ITDG specialists in stove testing and design was extremely valuable and represented broader experience than available locally or from the A.I.D. contractor. These ITDG inputs involved primarily standardized stove test protocols and stove design refinements. They significantly decreased wasted effort in researching outside experience and also prevented the project from "reinventing the wheel."

In addition, design innovations by the project adviser (e.g., introduction of the so-called "bell-bottom" shape) in response to field test results were also essential in perfecting stove models. The early project management decision to stress primarily self-sustaining private sector technology and dissemination strategies was also a key decision. This decision realistically compensated for the lack of both Government funds and personnel and made the commercial incentives for self-sustaining production the project's primary dissemination strategy. One negative aspect of this orientation, however, was to de-emphasize public promotion and publicity which, as already noted, remains to be a gap in the program.

PRODUCTION ASSISTANCE

Technical assistance and financial aid was offered to only four entrepreneurs/enterprises by the KREDP Project. This excluded Jerri International which received technical assistance only. This minimal level of support was not an implementation decision, but was primarily due to the lack of a financing mechanism for this purpose, coupled with insufficient time on the part of the project stove adviser to identify and work with new producers. Finally, small grants for tools and initial materials (Ksh. 500-1000/- each) were made to about 30 artisans to encourage improved stove production. Consideration was given to repayment, but no mechanism existed for the MOE or project contractor to receive and recycle funds.

Producer assistance by the KREDP was primarily aimed at non-Nairobi firms in order to spread the benefits of the improved stoves to other urban areas. A great number of both logistical and other problems were encountered in trying to distribute this

production technology. *In retrospect this orientation in support activity away from Nairobi was inappropriate, taking place at the same time the Nairobi commercial production was in its infant stage, and where no significant promotion program for this initial production in Nairobi had taken place.*

The criteria for the selection of non-Nairobi producers was also unrefined at this phase, and the technical assistance package (e.g., molding technology, clay selection and mixtures, and kiln construction) was ill-defined. The result was that few of those assisted had adequate motivation, management skills, financial resources, transport, etc., for sustained production. These problems persisted in the similar approach adopted by the ATI project after the KREDP project ended.

The extension activities aimed at the promotion of production via training at Government Agroforestry Centres were not really part of the mainstream dissemination activity of the project which concentrated on commercial firms. The Government Agroforestry Centre activities were designed to assist in spreading knowledge of the technology for manufacturing improved stoves regionally to informal sector artisans. *These activities suffered from a number of problems, including the lack of staff experience in production methods, clay selection and ceramics in general, and kiln design. The Agroforestry Centre based one to two-week courses were not adequate in duration to create the capability to undertake production in any case.*

Initially, the MOE project officer intended that these Agroforestry Centres produce commercially and compete with the private sector. This led to a confusion in objectives and to much wasted effort early in the project. This idea was ultimately dropped because Government procedures presented difficulties for procurement and staffing (i.e., there was no adequate provision for procuring waste metal drums and bricks for kilns and there were problems providing adequate wages to artisans). *Later, the success of those trained at the Agroforestry Centres also suffered (and still does today) from a lack of sound criteria for their selection, as well as the lack of a strategy regarding the further financial, technical, and marketing inputs needed to successfully produce the KCJ.*

Role of the Private Sector

The key to the early dissemination success of the project was the effective stimulation of private commercial interests and the substantial profits associated with stove manufacture. The ability Jerri International, the initial major producer of stoves assisted by the project, to organize and self-finance production, market, and innovate to improve its product was vital to its success. Jerri International was already a successful ceramics manufacturer at this time and had one of the few well-trained local potters. The firm had a small but suitable production site and a building containing storage area and potter's wheels and initially was able to use its existing electric kiln. The owner also had limited previous unsuccessful experience in trying to introduce clay stoves following the 1981 Nairobi United Nations Conference on New and Renewable Sources of Energy (UNCNRSE).

The key to Jerri International's success in production and dissemination can be attributed directly to several factors. These included the firm's high degree of interest in stoves and entrepreneurial (not technical) skill, the availability of risk capital to invest in materials and stove inventory, and the availability of staff and the willingness to devote management and marketing time. The availability of technical assistance on ceramic liner production from KREDP was also critical, and the experience gained in producing the project's initial order of 450 improved stoves for field testing was an important stimulus.

Another private firm attempting to start improved stove production obtained very different results. Clayworks, a substantially larger firm engaged in brick and tile manufacturing, initially had an interest in improved stove production. Clayworks' attempt at stove production suffered from numerous problems. Although the company was large and well-established, it required large production runs to operate its plant profitably. However, the initial stove market was small. In addition, the company had no experience in interacting with the informal sector, the traditional suppliers of metal claddings for stoves, or the retail outlets which were also small and dispersed. This aspect was particularly demanding of scarce management time and was never successfully implemented.

Clayworks suffered from quality control problems from inappropriate clay mixtures and stove failure/breakage because they failed to place a cement and vermiculite insulation between the ceramic liner and metal cladding. Clayworks was also explicitly excluded from technical assistance from the KREDP program by a Government policy decision (due to its large size and other considerations). It is unclear whether or not this would have made much difference given the other problems noted above.

Finally, upon the completion of the KREDP project, the project technical adviser set up KCJ production facilities of his own and soon became the second largest producer.

Role of the Informal Sector

Informal sector artisans and the informal sector marketing system have played an important part in KCJ implementation. This part has not been without its difficulties. The informal sector in Kenya is made up of a large number of very mobile and fiercely independent artisans. These artisans (referred to as fundi) do not easily accept significant changes in methods, materials, and technology. *The KCJ program benefitted greatly due to the KCJ metal cladding's similarity to that used in the existing metal jikos.*

The Nairobi fundi works almost exclusively as an individual, not readily allowing for either significant specialization and division of labor or expansion by the adoption of technology that would require the cooperation of many fundi. Similarly, the lack of working capital and lack of permanent facilities made it infeasible for the fundi individually to purchase adequate materials and significant numbers of clay liners for them to store significant numbers of finished products. The early efforts of the KREDP program to train artisans in an effort to stimulate fully integrated stove manufacture was unsuccessful due to these characteristics.

Informal sector-based production has also made quality control of metal claddings and assembly difficult. The manufacture of metal claddings for stoves by a large number of artisans not identifiable by consumers, even with adequate quality and brand markings on ceramic linings, has made it hard to maintain assembly and metal cladding quality. On the other hand, since the fundi is satisfied with much lower returns and earnings than a formal firm, informal sector participation helped to keep stove prices down.

The informal sector's ability to satisfactorily produce improved stoves has a number of other potential consequences for stoves projects. In many cases, charcoal stoves will be found to be used by low income families. For these families the price of the stove is a major factor in their purchasing decision. *Where the informal sector is able to produce satisfactory traditional or improved stoves from scrap material for the low-income market, it is unlikely that any large firm will be able to mass produce and underprice the informal sector. Therefore, where the informal sector is already in the stove production business, it is unlikely that any separate formal sector or government program will be able to compete.*

Subsidies and Stove Pricing

There were no explicit subsidies provided in the A.I.D.-sponsored KREDP project, although a very small number of producers and artisans received minor financial help, such as materials supply and initial stove orders, as well as technical assistance. The most successful entrepreneur at the close of the formal A.I.D. stove project in 1984 received almost no financial assistance. Assistance subsidies were primarily in the form of free technical assistance and training provided by the project. Direct subsidies of production to lower stove prices and, thereby, to increase sales, were not considered since they directly conflicted with the project's main goal of developing self-sustaining production.

Price controls over stoves were proposed by various parties during the course of the project to limit "excessive" profits of producers, but none were ever seriously considered or imposed. The evidence which does exist indicates the opposite of what the price control advocates would have expected. *That is, high prices induced competition which drove prices down (albeit with a lag), while low prices tended to result in the exit of producers from the market.* Even in 1988, substantial price competition is still occurring and prices have declined from about Ksh. 70-80/- for the standard 10-inch jiko in 1985, to about Ksh. 60/- in 1988. This represents a significant decrease in both nominal (market) and real price terms. *It is likely that the imposition of initial price controls would have been very detrimental to the spread of the KCJ technology before it achieved any significant market penetration.*

PRODUCTION AND DISSEMINATION

The dissemination goals of the KREDP expanded as the project exceeded the initial limited goal of producing 5,000 improved stoves. Goals were revised as follows:

1. To develop a large number of technicians, trainers, and extension workers who would be skilled in stove production, promotion, and monitoring and evaluation.

2. To create a network of stove artisans and entrepreneurs skilled and involved in the fabrication and repair of improved stoves.

3. To achieve a large-scale adoption rate of proven improved stoves.[2]

These goals presumed that small-scale production and dissemination was an appropriate strategy. They also incorporated Government policy in terms of promoting employment and the informal sector. This policy contributed to some mis-direction as Government training sessions for artisans produced little in the way of follow-up production. Assistance given to medium-scale entrepreneurs, on the other hand, produced much better results, including the additional employment of artisans.

The interaction of the formal and informal sectors has been critical to the Kenya program in two respects. First, the small initial size of the KCJ market, coupled with the low-cost and effectiveness of artisan metal cladding production, combined to give producers an ideal production capability-market size match. Producers, by subcontracting metal cladding, avoided costly investment prior to the market's development; yet they were reasonably able to increase production as the market grew. Second, given the fierce competition characteristic of the KCJ program, producers were unwilling, and would have been unwise, to invest heavily for metal cladding capability early in the project. Only as the market expands and producers gain confidence in their market shares and encounter significant problems in achieving reliable and adequate supplies, will they be willing to invest in production to displace current metal cladding artisan systems. *It is important to point out that a reliance on artisans for improved stove production may or may not be an effective strategy for a stove program. The appropriateness of any strategy depends on the specific local circumstances. It is preferable in designing a dissemination strategy therefore, to permit as much flexibility as possible in the organizations/firms to act as producers within broad policy guidelines.*

Training

Training activities included informal on-site training by the project staff and later KENGO, formal training workshops and seminars for trainers, and in-service training at MOE Agroforestry Energy Centres. Training activities were always difficult to evaluate since the ultimate goal of stimulating commercial production was hard to measure. In 1986 it was reported that over 200 artisans had been trained by the KREDP. Few of them, however, were able to translate their training into improved stove enterprises. This was due to a number of factors, the most significant of which was undoubtedly the inability to manufacture ceramic liners.[3]

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[2] Maxwell Kinyanjui, The Kenya Charcoal Stoves Program..., p. 20.

[3] Energy/Development International, Improved Stoves in Kenya, Kenya Renewable Energy Development Project (August 1986), p. 15.

A number of factors contributed to the lack of success of the Agroforestry Centre-based training, including the following:

1. Trainers themselves were not successful stove producers, and if they had been, they probably would not have been interested in acting as trainers due to the low pay.

2. Lack of definition of a technology transfer strategy, and failure to tailor training to support this strategy.

3. Initial training occurred at a time when the technical production package was still under development, and current training is still not up-to-date.

In retrospect, the goals and approach to training should: a) be designed within the context of the appropriate dissemination strategy; and b) require training in skills for the manufacture of improved stoves only for trainees connected with individuals or firms which could organize production, finance manufacturing, and undertake marketing.

Promotion and Public Information

There was no explicit, consciously designed or well-funded public information activity on the part of the KCJ project. Mass publicity for the improved stoves was often a by-product of other activities; for example, the inauguration ceremonies for Agroforestry Centres, Harambee (self-help) fund raising events, or community-based stove project initiation. Initially, these were important and useful vehicles for promotion. In addition, limited stove demonstrations in open air market places, trade fairs, and public institutions generated a great deal of interest. However, the lack of funding precluded a major public information campaign. There was also a conscious effort by project management to proceed cautiously in stimulating demand until production capability could be developed. As noted elsewhere in this report, general knowledge of both how to choose a KCJ in the marketplace, and how to use the KCJ remains inadequate. *The absence of significant promotion of the KCJ over the last several years has also been detrimental to sales.*

Technical and Financial Constraints

One of the major technical constraints faced in KCJ development was caused by the failure of the original A.I.D. project designers to foresee the skill, facilities, and equipment required in the development, testing, and introduction of improved stoves. This led to the project's lack of an explicit provision for stove or materials testing equipment or facilities for stoves or materials. The art of stove development and introduction was, of course, in a very formative stage at the time the project was designed, and there was little consensus on stove design and testing principles, or on production approaches. The KCJ was, therefore, developed in a sub-optimal system in many ways. One consequence of these initial gaps is the continuing need for substantial continuing development of technology (e.g., the "jigger jolly" for molding ceramics, improved kilns, etc.), as well as the need for a better definition of the KCJ technology and production model for purposes of replication.

Ceramic Stove Production Issues

The determination of appropriate clay and other material additives to form durable and low-cost ceramic stove liners or stoves is still more of an art than a science. In countries with relatively mature programs, major producers have come up with pragmatic means to choose clays, determine which materials to add (such as sand), and methods of materials preparation and molding. These pragmatic solutions, however, have reportedly led to wide variations in durability, and do not form a readily transferrable body of knowledge to new local producers, or to other countries where clays and other material conditions differ.

It has been found that acceptable ceramic quality can be achieved where good clay exists and local ceramic production is relatively mature. Nonetheless, there is a need for additional analysis of appropriate materials and production methods for ceramic stoves or liners to assist stove programs throughout Africa. It is reported that the Overseas Development Administration (U.K.) is supporting a research program with ITDG aimed at developing standardized methods for the selection of stove clays and addition of other materials to make durable stove liners.

FUNDING

A.I.D. funding for the development and introduction of the Kenya Ceramic Jiko amounted to about $160,000 over roughly a two-year period. Significant local in-kind support was received from other sources, principal among which were non-Governmental organizations such as KENGO, the KU-ATC, the ITDG, and from the MOE. This funding level, however, did not provide adequate test facilities, only minimal test instruments, and only a small budget for materials. There was also inadequate allowance for market surveys, follow-up monitoring and evaluation, and public information and publicity. Finally, the project had only one full-time adviser for development and dissemination of production technology on improved stoves and charcoal kilns, although minor funding was eventually provided for technician support. *This level of support is far below what budgets for replication of this type of effort involve today and, as indicated by the remaining gaps in this program described in recommendations above, were not adequate for properly completing this effort.*

Energy Development Fund

A so-called Energy Development Fund was provided for in the KREDP project, to be administered by the MOE to assist in the demonstration, production, and commercialization of renewable energy technologies. Unfortunately, the Fund never became fully operational. Only two grants, both to KENGO, were made from the fund. One was used to finance the field test of the improved stove. The institutional complications of implementing this first-of-a-kind development grant and loan fund were never resolved and funds eventually were reprogrammed. The MOE has only recently (1988) been able to get specific legislative authority for the administration of a similar fund and intends to proceed with implementation.

In retrospect, it appears that in order to have been successful the fund would have needed more flexible criteria for aid to allow new and/or informal sector enterprise or individuals to have received financial or materials assistance. It would have also greatly simplified implementation if there had been independent (preferably non-governmental) administration to avoid Government bureaucracy and procedural complications. In addition, more intimate involvement by groups with closer linkages to intended beneficiaries (with independent financial review) would have added needed urgency and generated a larger number of qualified proposals.

COORDINATION BETWEEN PARTIES INVOLVED IN STOVE ACTIVITIES

Initially coordination among parties working on improved stoves in Kenya was inadequate and sometimes more competitive than collaborative. Groups working on improved stoves included the KREDP in the MOE, the Bellerive Foundation, and UNICEF. Each had its own approach to stove design and dissemination and there was often disagreement over the approach being undertaken by others. This problem was partially resolved by the establishment of an interagency Technical Committee on Fuelwood Conservation within KENGO. This group continued to function intermittently for several years and was a useful forum, for example, for the resolution of issues concerning testing methodology. However, given that it did not have explicit funding or staff to support its operation, its role was severely circumscribed and its operation was very irregular. *A stronger national information exchange and coordination mechanism is still needed, including a realistic role for Government, determined both by its policy and staff commitment to the activity.*

IMPACT EVALUATION

Evaluation of the KREDP project at the termination of the stove component did not occur. Evaluation at that stage and later should have been undertaken to document actual energy savings realized, stove durability, social and environmental benefits, numbers of stoves sold, and economics and effectiveness of different production methods, among other topics. The success of this project is evident in the self-sustaining nature of the commercial production of improved stoves which is still growing today. However, the lack of a strategy for program expansion and for directing the activity to help achieve national resource conservation goals was a significant deficiency which remains today.

ATI'S CERAMIC-LINED JIKO PROJECT

The Ceramic-Lined Jiko Project sponsored by ATI and executed by KENGO and Miaki Jikos, Ltd., has been the only major follow-up project to the improved charcoal stove program initiated by A.I.D. The ATI project was very closely related to the KREDP project in that it sought to promote the KCJ, utilized very similar production technology, and involved some of the same participants. The ATI project, however, pursued a different management and dissemination strategy. In trying to extend certain aspects of the KCJ experience (e.g., support to small-scale rural production units) the ATI project provided several lessons which are a valuable supplement to the KREDP experience. A brief assessment of that experience is presented below.

The stove component of the KREDP was predominately concerned with defining market needs, identifying and developing improved stoves, and initiating private sector production and dissemination. The ATI project, on the other hand, focused on the establishment of additional production units in the informal sector to help bring about widespread use of improved charcoal stoves. It was also intended to take an initial step in the dissemination of improved wood stoves. Specifically, the ATI project was designed to

1. provide financial assistance to existing informal sector manufacturers of traditional jikos to begin production and marketing of ceramic-lined stoves in 20 dispersed locations;

2. provide technical and marketing assistance to the production units; and

3. field test 200 improved ceramic-lined wood stoves. (This aspect is omitted from the discussion here since it was not implemented.)

The ATI Ceramic-Lined Jiko Project was originally budgeted at Ksh. 3.5 million (from ATI), with KENGO to provide Ksh. 0.8 million (a major portion of which was to be funded by NORAD). Eventually, due to the failure to receive NORAD funds, ATI increased its budgeted contribution by Ksh. 560,000/-.

The ATI project encountered a number of technical and management difficulties leading to its premature cancellation in 1986. There appear to have been four basic problems experienced by this project. The first was caused by the determination that assistance would be given only to small-scale dispersed production units (which proved to be difficult clients). This problem was compounded by the lack of adequate criteria for selection of producers. Second, problems arose with the delivery of project support to producers, stemming from both an inadequate package of technical assistance and inadequate administration of financial assistance. Third, the technical support staff had a conflict of interest and spent inadequate time on the project. Fourth, problems were encountered in overall management and administration of the project.

The official review of this project, commissioned by ATI, provides a thorough non-technical evaluation of the project after its suspension in 1986.[4] The evaluation reported, among other things, that of the nine subprojects given assistance by mid-1986, two did not start production, three went out of business within four months of project support, and only three others remained in operation. These last three accounted for only 27% of total loans. The delivery of technical and marketing assistance is criticized by the ATI evaluation, both in terms of completeness and appropriateness. The ceramic liner production process appears to have been the most significant technical constraint, being

[4] Godfey Kaduru, Accelerated Production and Dissemination of Improved Jikos in Kenya (Nairobi: Partnership for Productivity Service Foundation, March 1987).

complicated by the varying nature of local clay deposits, necessary preparation and mixing, and firing.

In retrospect, the technology of ceramic jiko production was still relatively immature at the time the KREDP project ended. The technical package to be delivered would have benefitted greatly if the ATI project had begun with a further refinement and standardization of technology for production before embarking on large scale dissemination. This in fact did later take place, but at the same time as promotion, and this technical package ultimately reached only one producer.[5]

The ATI project exemplifies several important and basic problems with the technical assistance available in East Africa in the household fuels area. *The problem is a scarcity of local technical and promotional capability. This scarcity results in the need to use entrepreneurs and producers as technical resources, which concomitantly produces both a conflict of interest and incompleteness and/or inadequacy of technical inputs.* While most experienced practitioners of improved stove dissemination are the small group of entrepreneurs who have succeeded in making this a profitable business, this group, at the same time (understandably), has been shown to be reluctant to share complete information on either their technology or marketing practices. Producers are also likely to be lacking in the broad technical capabilities needed to develop new production in other countries or dissimilar local environments.[6]

The need for a pragmatic and well-reasoned selection criteria for producers to receive project support appears to be one of the most important lessons from both the ATI and the KREDP projects. Production requires capability to provide organization, transport, and working capital. The additional requirement of the ceramic stove, that is, for subcontracting for cladding manufacture also requires organization, transport, and quality control. Such financial and business management capability is scarce and difficult to identity in small enterprises. Efficient, large-scale liner production also requires ready access to materials including clay, sand, and vermiculite, as well as substantial markets. Prior to providing assistance to establish a new stove production unit, an evaluation of the overall commercial viability of the enterprise is needed, including an assessment of the business capability of the producer.

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[5] This technical package was developed by ATI's Hugh Allen and incorporated a motorized ceramic molding machine, pulverizer, pug-mill, and efficient brick kiln. Only Wambugu's Tigoni production unit received this package.

[6] This requires the ability to define markets and users' preferences; to design, test, and develop new stoves suitable to local conditions; to identify appropriate producers; to develop and transfer production technology; and to be able to offer private marketing and public promotion assistance, among other things.

LESSONS LEARNED FROM THE OVERALL KCJ EXPERIENCE

A number of elements of the KCJ experience were particularly important to the results achieved and are summarized below. These include the following:

1. Initial screening and stove development work. Early screening of stove models for testing, and later promotion, was carefully done under very pragmatic selection criteria stressing cost, consumer acceptance, ease of production, and commercial viability.

2. Market assessment. Effective evaluation of the target market, including determination of desirable characteristics for the improved stove, was effectively accomplished by both formal and informal means. This input was critical for the later acceptance of the stove as borne out in field tests and later commercial sales.

3. Field testing. Field testing was vital to help overcome design problems, verify energy/financial savings in actual practice, and to determine acceptance and response. Although field tests and analysis were only rudimentary, they were adequate to answer basic questions of suitability, savings, and quality.

4. Project objectives. Clear project objectives, that is, A.I.D.'s requirement that the project develop a self-sustaining stove program and achieve a significant level of commercial production within 18-24 months (reinforced by pressure from the MOE to disseminate stoves as soon as possible), provided a strong incentive to the KREDP stove program to minimize experimentation and find sustainable and economic designs and effective local collaborators.

5. Role of the informal sector. Involvement of the existing traditional stove production sector both as assemblers and as a source of artisans was extremely useful for

   a. providing a production network already in place and capable of good quality metal components;

   b. effective marketing through traditional systems; and

   c. supply of a low-cost labor and low-overhead assembly system.

   Metal working artisans appear to be an essential component of initial stove production systems. They keep investment levels for ceramic liner producers low and provide flexibility to rapidly increase output, while representing a management challenge to control. It appears that only after significant market maturity and expansion could this system be displaced for economic and management reasons. It is probably much wiser to establish alternative

metal cladding fabrication capability only when market size and market share can clearly justify this investment.

Where the informal sector is able to produce satisfactory traditional or improved stoves from scrap material for the low-income market, it is unlikely that any large firm will be able to mass produce and underprice the informal sector. Therefore, where the informal sector is already in the stove production business, it is unlikely that any separate formal sector or government program will be able to compete.

6. Technical and management assistance. Full-time, project-funded technical assistance, specialized outside assistance (i.e., ITDG), and availability and use of outside laboratory and other equipment and facilities not provided for adequately in the project, were essential to the project. These helped to identify and evaluate prototypes and re-design as needed, to manage field tests, locate and train producers, and resolve other technical hitches.

7. Role of NGOs. NGO input was very important to the project to provide for organization and management of initial field tests, help locate entrepreneurs, and for the extension and development of production units. NGO inputs were also very cost-effective.

8. Government's role. Government was reasonably effective in providing overall policy and guidance. However, it was ill-equipped for working with the private sector and small-scale entrepreneurs, and it was understaffed and under-equipped to provide a significant technical or financial contribution. The unavailability of Government funds and complex administrative systems made it very difficult to operate a development and outreach program.

VIII. GUIDELINES AND ISSUES FOR THE IMPLEMENTATION OF FUTURE IMPROVED STOVE PROGRAMS

An improved stove program is only one of a number of options for responding to a household energy problem. Other alternatives may include: modification of government policies such as those regarding relative fuel prices, the production of new biomass supply and the substitution of alternative fuels, and/or increasing the efficiency of charcoal conversion. An improved stove activity, therefore, should be considered a part of an overall household fuel program. Within this context, a stove program can be designed as a more effective option, with realistic goals, and be consistent with government policy.

INITIAL QUESTIONS

Within the household fuel planning process, the design of an improved stove activity should address several basic questions:

1. What is to be the target market (e.g., urban charcoal versus other fuels or rural woodfuel)?

2. Is an improved stove program likely to achieve the intended fuel savings and/or social objectives at a reasonable cost?

3. Who should provide the leadership for the program, and what should be the respective roles of the participants; for example, in stove development and testing, production promotion, quality control, and market development?

4. What type of improved stoves should be promoted?

5. What scale of production and what production technology should be utilized?

6. Should the government provide direct or indirect subsidies, incentives or other financial support to consumers or producers, and if so, how?

GENERIC PROGRAM COMPONENTS

The following summarizes the major components that should be included in a comprehensive stove program, with specific reference to East Africa:

1. Assessment of the Biomass Resource Base and an Assessment of Charcoal and Woodfuel Utilization and Markets

Assembly and analysis of detailed information on supply and demand for household fuels is the essential first step in project formulation. This information is critical to determine both the need for, as well as the content and structure of, any improved stove project. This information helps to identify prospective characteristics for new stoves, such as price, size, weight, materials, functions to be performed, etc., as well as to estimate prospective project impacts and stove market. Necessary information should include

a. economic and demographic information, such as population size, geographic distribution, and income levels;

b. fuel supply and cost, such as types, sources, reliability of supply, and relative fuel prices;

c. fuel use characteristics, such as consumer cooking, fuel use, dietary, and related socio-economic characteristics; and performance and utilization patterns of existing cooking devices; and[1]

d. traditional stove production and distribution systems, materials sources and costs, and marketing practices.

2. Prototype Development and Testing Facility

Prototype review is intended to identify candidate stoves and test efficiency, durability, cost, feasibility of production, consumer acceptability, and materials. Capability should also be developed to establish minimum material and quality standards based on cost, durability, and efficiency.

Test and development activities required include the following:

a. Stove testing, including the evaluation of prototypes and the definition of criteria for evaluation, identification and procurement of instruments, equipment and suitable facilities; and the definition of laboratory and kitchen testing protocol (e.g., user acceptability, efficiency, cooking time, ease of ignition, safety, durability, etc.).

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[1] For more specific requirements see, J. Leitman, Some Considerations in Collecting Data on Household Energy Consumption, ESMAP (The World Bank, 1988).

b. Field testing, including measuring fuel use and efficiency, evaluating relative usage levels, durability and quality of stoves, and determining users' preferences and perceived problems.

c. Monitoring and evaluation, including determination of durability and overall quality of materials and construction, assistance in estimating sales and market penetration, and modification of prototypes based on the evaluation of users' preferences.

3. **Production**

Systems and equipment for the manufacture of improved stoves must be identified, evaluated, and improved upon. For ceramic stoves, the production program must include the development of criteria for clay selection and mixture, molding and preparation technology, and kiln construction and operation. Design and implementation of a pilot stove production and dissemination project is necessary to ensure that both production and dissemination systems function properly, and to fine tune and evaluate these systems based on actual performance.

4. **Dissemination Strategy**

A dissemination strategy is essential to provide the criteria for the identification and evaluation of prospective private sector producers (particularly for ceramic liners) and to establish the credit and technical assistance mechanisms by which the program will support commercial production and marketing. Since attaining a self-sustaining production and marketing system is vital to success, this is a key element of the program.

Finance is a particularly important aspect of commercializing production. Evaluation of the availability of financing mechanisms and accessibility of credit and working capital need to be an integral part of producer selection. Potentially, financial support may form one element of the program's assistance package for producers.

Sound and locally adapted criteria for producer selection are essential and should include: entrepreneur experience and skill (e.g., marketing), management and financial capability experience in similar enterprises, availability of transport, technical capability, access to materials (e.g., for ceramic stoves, clay and fuel for firing liners), access to markets, and finally, motivation as reflected by a willingness to commit both time and finances.

5. **Quality Assurance**

A quality assurance program or strategy is needed and is particularly important when relying on commercial systems as primary mechanisms for the production and dissemination of stoves. The program might involve assistance to, and monitoring of, producers as well as information to assist consumers make informed purchases. Such a

program must be carefully tailored to local circumstances, particularly to institutional capability. The following elements should be considered:

a. Consumer information and education on how to select stoves for quality and on proper use of stoves. This should involve use of locally appropriate media, e.g., radio, newspaper or posters/brochures distributed to market outlets, and education via the school system and consumer (women's) groups.

b. Training of producers and artisans in production techniques and materials and on the importance of quality.

c. Monitoring and testing by appropriate Government or consumer (or other) groups to determine quality and identify problems and to feed this information back to consumers and producers.

d. Standards development, monitoring, and possibly enforcement. Standards, if adopted, require substantial resources to develop, are costly to administer, and, given a negative connotation with producers, may be difficult to enforce. A related and more positive option is certification of producers meeting established standards, along with (one option) the furnishing of an "approved decal" for display. The certification process would still require careful monitoring and regular inspection. Either system could be self-financing via fees for evaluation.

6. <u>Training</u>

Training activities are needed for expanding the number of manufacturers and artisans capable of producing improved stoves. In addition, following the development of an appropriate local strategy for quality control and monitoring and evaluation, the training activity should be used for implementing remedial measures (e.g., improving ceramic mixtures and molding, modification of stove dimensions, etc.). Attention also needs to be given to the development of an adequate number of professionals knowledgeable in improved stove development and testing, production technology and dissemination, and capabile of training producers and artisans. Consideration should be given to the use of expertise or facilities already in the region (e.g., East Africa), rather than to the creation of highly specialized capability in each country (see discussion later in this section on regional technical capability).

Specifically, training is needed in the following areas for program staff as a basis for the training and technical assistance to producers:

a. Technical areas such as stove design and testing, methods of production and materials testing, and in training of producers and artisans.

b. Field test design analysis and survey techniques and monitoring and evaluation issues and methodology.

c. Production and dissemination training, for example, production equipment design, fabrication, and utilization. For ceramic-using stoves (for some selected staff), training in clay selection, preparation, molding and firing, as well as kiln construction. In addition, some staff training should be provided to develop business finance and administration, and marketing and general promotion skills.

d. Training for the staff involved in management, as opposed to technical areas, should include a basic orientation in the above areas, plus an overall appreciation of the goals and objectives of household fuels programs. This is needed to instill the capability to guide both the current program and to adjust it as times change, and to define new programs as needed to respond to future conditions.

7. **Marketing and Promotion**

A marketing and promotion assistance activity is needed to spread awareness of improved stove availability and benefits (to augment producers' efforts), as well as to broaden knowledge of production technology and commercial stove production opportunities.

Promotion activities might include the following:

a. Media: Including radio programs, articles and advertisements in daily newspapers; slide shows and films, school educational materials, NGO informational material (e.g., women's groups newsletters), and general information pamphlets or fliers.

b. Demonstrations: At agricultural shows, on market days at public markets, and before women's group meetings, etc.

c. General publicity: Through public statements of Government leaders and opinion leaders, in speeches, and other forums.

d. Finance or credit: Innovative credit programs such as salary deductions paid directly to stove vendors on behalf of employees purchasing stoves (for government or reputable company employees).

e. Contest and competition: Contests for the best designs, promotional or educational ideas, or offering prizes for the sale or marketing of improved stoves may also be useful.

8. **Monitoring and Evaluation Component**

Monitoring and evaluation is needed for stove production, project performance, and improved stove penetration and associated issues. This should include monitoring of sales

patterns and prices, stove penetration, consumer use, and stove quality, via surveys of households and producers. This information should initially be reflected back into prototype design refinements, and later into improvements in production models. In addition, appropriate technical coordination mechanisms with other programs should be provided for as a program component. Where to locate monitoring and evaluation, and coordination functions, e.g., whether in government, research groups, or NGOs, cannot be determined a priori.

9. **Project Design, Planning, and Budgeting**

Plans and budgets, as well as resources allocated, need to be adequate to ensure the effective execution of all the above functions. Care must be taken to think through the scope of each phase, allowing for administrative and recruitment delays, training time, staff attrition, and the need for both local and international procurement. It is also extremely important to build flexibility into the plan, both to allow reallocation of resources as learning permits more refined costing and definition of tasks and as new requirements are identified. The duration of a new project likely needs to be four or more years for a major stove project (the KREDP originally had only an 18-month stove program; it was later extended to 24 months).

MAJOR CONSTRAINTS TO THE INTRODUCTION OF NEW TECHNOLOGY

The effective implementation of new and more appropriate technology in developing countries is dependent on a number of factors. These include the objectives of firms or individuals targeted as implementors, the resources available to firms and prices for resources, the nature of the industry/business and of the market, and the knowledge of technological alternatives. Stove manufacturers face numerous technical and financial constraints in initiating and conducting their businesses. These constraints and some of the actions required for their resolution are summarized below.

1. **Policy Environment**

Since donors and governments can affect only a small number of enterprises directly, it has become an accepted premise that the best way for Government to stimulate the adoption of innovation is to establish appropriate broad policy conditions, e.g., prices, credit policy, import preferences, etc.[2] Government, rather than encouraging, often actually discourages small enterprise by a combination of policies favoring larger industry such as

[2] Francis Stewart, ed., Macro-Policies for Appropriate Technology in Developing Countries (Boulder & London: Westview Press, 1987), p. 1.

subsidies, legitimized monopoly, and access to foreign exchange. This bias in favor of large formal enterprise needs to be modified or removed in order to encourage stove enterprises, as well as small enterprise in general.[3]

2. Insufficient Initial Market

Widespread promotion and market development are both costly and difficult for individual producers to undertake without outside support. There is also a need to establish standards and provide education to consumers on stove use and selection to both enhance consumer confidence and promote quality control. The government should play a prominent role in resolving these constraints. The individual producer has neither the resources nor the incentive to broadly promote improved stoves since his promotion may also benefit his competitors because his product is not sufficiently differentiated from theirs.

3. Finance

The vast majority of financing for small enterprise comes from the entrepreneur's own funds or retained earnings. Conventional financing schemes are poorly adapted to deal with such enterprises, and small enterprises are reluctant to deal with such a cumbersome and inappropriate system. Lack of capital was almost universally cited as a handicap in the establishment of new or expanded stove production in Kenya.[4]

Loans to assist small scale enterprises are more difficult to administer but have been found to be feasible, if certain principles are followed. First, loans should be primarily for working capital (since small firms have relatively greater working capital as opposed to fixed capital financial requirements). Second, loans should be screened quickly on the basis of character, not based on feasibility studies or provision of collateral (this is closer to the mode of operation of the informal sector credit system). Third, smaller loans over shorter periods should be provided, with a reward in the form of larger loans after successful repayment. And fourth, interest rates should be set high enough to cover operating costs and reflect the true scarcity of capital in order to both ensure the commitment of the borrower to the enterprise and reflect the scarcity of capital.[5]

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[3] Carl Liedholm, The Private Sector Connection To Development, Michigan State University, International Development Paper (1986).

[4] As an example, one KCJ producer became frustrated when trying to obtain finance for a vehicle from normal banking sources which demanded an equivalent deposit as collateral.

[5] Agency for International Development, Future A.I.D. Directions in Small and Micro-Enterprise Development, Report of a Workshop Held in Williamsburg, Virginia (April 1987); Dennis Anderson, Small Industry in Developing Countries, World Bank Staff Working Paper, 518, 1982, pp. 48-58; and J.M. Page, Jr. and William F. Steel, Small Enterprise Development, World Bank Technical Paper No. 26, 1984, pp. 29-30.

4. **Availability of Technical Assistance**

Lack of a testing and development capability for identifying improved stove prototypes and for further refinement of these is a major constraint for new projects. Furthermore, the lack of adequate knowledge of production systems and appropriate technology is a serious impediment to the commercialization of improved stove designs. The lack of standardization of the technology package and the transfer of out-of-date techniques, for example, have also been major problems in Kenya.

5. **Local Institutional Capacity**

The lack of sufficient local institutional and financial capability are two of the most severe constraints in the introduction of new technology and the promotion of new small business. Further external assistance in stove development and promotion in Kenya appears needed, and this seems to be the case elsewhere in Africa as well.

There is a serious debate, however, on the nature of external assistance. For example, should funds be primarily provided to governments or NGOs or the private sector? Should this assistance stipulate expatriate involvement for administration, or additionally, for testing and design, and production technology development, etc.? Should assistance be oriented primarily to the support of local institutions?

The development of improved stoves in East Africa will require a mix of external assistance and support for local institutional development, with a close matching of local circumstances to the package to be provided. In Kenya, for example, the KREDP provided a good mix of long-term expatriate management, local development and promotion, and short-term external technical assistance (within Government's policy support). A review of the current Kenya situation suggests a continuing need for assistance, but for a different set of skills and financial inputs than originally provided (see Section VII).

Since the development of local institutional capability is so important yet so difficult, it is suggested that future energy conserving stove programs stress training and hiring of local staff and consultants and provide expatriate assistance primarily for program design, management, and specialized technical assistance.

Motivation is perhaps the most critical factor in success. In order for national stove programs to proceed effectively, the improved stove area must be seen as: a) an important national priority, leading to adequate commitment of government resources and policy support, b) an area of professional opportunity for technical assistance personnel thus leading to their commitment, and c) an area of great profitability by manufacturers, distributors, and retailers leading to their commitment, time, and money.

Ultimately, since the introduction of an improved product requires a commitment of time and money from manufacturers and distributors, an effective strategy for involving

and motivating this group is also of paramount importance.[6] Risk bearing as a factor in successful entrepreneurship appears to be an overwhelmingly important factor. There appears to be no substitute for substantial equity and personal commitment (i.e., which may mean full-time work or personal investment) in achieving success.[7] Technical assistance and promotion are necessary conditions, but they are not sufficient. They must be supplemented by motivation on the part of those in the production system.

IMPLEMENTATION GUIDELINES

Insights gained from the implementation experience with the Kenya Ceramic Jiko are summarized below, along with lessons from several other studies on small enterprise promotion. Experience reported in other small enterprise studies bears a striking similarity to the lessons learned from the introduction of the Kenya Ceramic Jiko. In general these lessons suggest that successful business promotion should exhibit the following characteristics:

1. **Assistance should be targeted at firms which meet most criteria required for success.**

In past successful efforts at small enterprise promotion, it was found in many cases that there was only a single "deficiency," as opposed to multiple needs (e.g., finance, business development assistance, technology training, etc.) which needed to be mitigated in order to ensure success. Rates of success differ markedly in cases where a large set of inputs (such as, technical assistance, financial aid, business management development, etc.) was required. Likewise, existing firms have a much higher rate of success than new small firms.[8] This finding parallels the KCJ experience directly, specifically in the successes of Jerri International, Jerri-Miaki, Waka Ceramics, and Jiko Bora.

2. **Technology, technical assistance, and other inputs should be similar to those currently used by the industry.**

A particularly important aspect of technical assistance in the KREDP was effective support to existing informal sector stove producers. In most African countries, charcoal stoves are used most heavily by low income families and are frequently made by informal sector artisans, using scrap or very inexpensive materials. Replacement of traditional stoves by improved products is likely to require the use of the same manufacturers and the same or related production and marketing systems. The experience in Kenya followed this pattern. The ability of the Kenya program to interact effectively with this artisan and small-manufacturing group was extremely important to eventual success. Stove designs,

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[6] Issues of management capability, credit and technical assistance to stimulate these entrepreneurs are discussed elsewhere.

[7] Peter Kilby, Small Scale Industry in Kenya..., pp.62-63, and 82-83.

[8] Carl Liedholm, The Private Sector Connection to Development, Michigan State University, International Development Research Papers, Reprint No. 1, 1986, p.9.

manufacturing methods and materials were based on traditional approaches and, therefore, relatively easily adopted.

3. **Surveys are needed to develop stoves and identify target producers.**

Surveys of the stove market and existing industries should be undertaken to understand the market and to determine the type and amount of assistance needed by producers; i.e., to determine what the missing ingredients are. The KREDP conducted three specific surveys and/or studies for this purpose before initiating technical assistance development (or even hiring a stove advisor). The project also built on the advisor's extensive past experience.

4. **Proven and existing organizations should be built upon.**

Successful projects have been built on existing organizations (or firms) and, in some cases, public institutions. Frequently, cases are cited where government is an inappropriate source and trade or industry associations are more effective. NGOs can in some cases, be another vehicle for implementation. The KREDP was successful in working with existing producers, that is, Jerri International, while it was less successful in stimulating new business to enter the market. Attempts, on the other hand, to build a new capability in Government showed very mixed results.

5. **Technology and products should be adapted to the local environment.**

Attempts to introduce product designs drawn from other countries, even other developing countries, with minimal adaptation has generally not worked well. In Kenya, relatively unsuccessful attempts to introduce wind machine technology without adaptation were far surpassed by an imported technology carefully adapted to local circumstances (Kijito machine of Bobs Harries Engineering). The KREDP greatly benefitted from its local staff who were familiar with the local consumer and the informal production system. It received outside assistance from ITDG which provided access to foreign technology developments which were adopted by the KREDP's local staff. In another example, in the Philippines (with a surplus of labor) a rice thresher developed by the International Rice Research Institute was less successful than in Thailand (with more scarce labor).[9]

REGIONAL REQUIREMENTS FOR ENERGY EFFICIENT STOVES (AND HOUSEHOLD FUELS) PROGRAMS

The World Bank and other donors are funding a substantial number of improved stoves projects in Eastern and Southern Africa. Projects have been implemented or will soon commence in twelve East and Southern African countries. A.I.D is currently funding a program in the Sudan and has funded programs in Somalia, Rwanda, Kenya, and

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[9] Bart Duff, "Changes in Small Farm Paddy Threshing Technology in Thailand and the Philippines," in Francis Stewart, ed., Macro-Policy For Appropriate Technology in Developing Countries, (Boulder & London: Westview Press, 1987), pp. 95-139.

Botswana. Even with the growing number of stove programs in East and Southern Africa, however, local technical capability to service these programs has not increased adequately to meet needs. For example, even with ceramic charcoal stoves and/or rural ceramic woodstoves being produced in the Sudan, Somalia, Kenya, Rwanda, Tanzania, and Malawi (all derivatives of the KCJ), there is an inadequate specialized skill in the clay selection, mixing and testing in the region.

Capability appears to be most needed in the following areas:

1. Market analysis, household energy surveys and marketing.

2. Stove and material testing, and stove design.

3. Stove manufacturing and production, and dissemination of production capability.

4. Household fuel program design, and project monitoring and evaluation.

5. Training (in all the above).

THE CASE FOR A REGIONAL "FACILITY" FOR IMPROVED STOVES AND HOUSEHOLD ENERGY CONSERVATION

The present path of stove development in Eastern, Central, and Southern Africa, which is heavily dependent on external support, is not only not cost-effective, but lacks long-term sustainability. The costs of having a dozen improved stove programs in the region served and supported by different technical specialists from Western European and North American countries is far greater than the cost of providing similar local services. Most donors have shown considerable willingness to utilize regional stove technical services and facilities when they are available and of good quality. Adequate support to develop this capability however has not yet been forthcoming.

The A.I.D.-funded Regional Improved Stoves Program (Energy Initiatives for Africa Project) recognized the regional need for shared information on improved stoves and established a regional network, based in Kenya, to

1. improve lines of communication and links between active stove players in the Region;

2. assist stove program managers obtain and develop needed technical skills;

3. serve as a link between national programs and the international community; and,

4. articulate regional needs for centralized support facilities.

The KENGO Regional Project was successful in improving communications and links in the region. It also served somewhat as a means for linking national programs with donor activities. However, the KENGO Project was weak in its ability to provide technical services to local stove agents and in its ability to improve on regional technical support facilities.

Regional Technical Capability Needed in Household Energy Conservation

While several improved stoves programs have "taken off" in the region, readily accessible regional technical expertise to replicate these results remains unavailable. As discussed elsewhere in this report, the concentration of expertise in commercial producers has serious limitations for replication and expansion of production. The following describes the major areas where problems are being encountered and where a greater regional capability is necessary:

1. **Market Assessment**

Most improved stoves programs in the Region have been developed without a clear understanding of existing stove markets (either on the production or distribution side). Consequently, stove program managers and stove producers often have little idea of the "true" market for their products. Assumptions are generally made on possible market penetration rates without good information on the size of markets, consumer preferences, or consumer ability to pay. This seriously handicaps both program design and effectiveness. Market research skills are scarce in most countries in the Region, but they can be found. Kenya and Zimbabwe have, for example, numerous commercial marketing firms. These skills could be built upon to better provide services within the region.

2. **Stove Design and Testing**

As noted above, there are about four times as many large-scale stove programs in the East and Southern Africa region as there were in 1982, yet regional testing facilities are still rudimentary. Moreover, nearly every stove program is in the process of developing, or will set out to develop, its own testing facilities. These will range from the relatively simple (Somalia) to the very expensive (the Sudan). While it is understandable that each country should have its own local facilities for basic testing, it is a very expensive proposition for each country to have all the facilities for extensive stove design, and materials and stove testing. It also appears that increasingly stove programs are turning to Europe and North America for specialized expertise which, by now, should have been developed and institutionalized locally.

3. **Ceramics Liner Manufacture**

Ceramics manufacturing has become a major issue in improved stoves programs, particularly for those closely modeled on the Kenya program. Technical issues focus primarily on clay selection, mixing, molding, firing, and quality control and testing. Numerous strategies have been adopted for attempting to achieve and maintain quality in

ceramics manufacture, ranging from providing specialized technical assistance in ceramics manufacture to attempts to limit the number of producers and suggestions for the establishment of standards or certification via labeling (for example). Even in Kenya, with the oldest program, quality control remains an issue particularly for new producers due to the lack of technical assistance in clay selection, testing, and development of simple methods to replicate these tests.

4. Stove Program Design, Dissemination, and Evaluation

Perhaps the biggest gap throughout the improved stove field is the capability to transfer the technical and manufacturing lessons to commercial producers and promote successful marketing and dissemination. Not only has there been very poor success in general in dissemination, there is also lack of careful monitoring, evaluation, and learning associated with most stove activity today. Even the relatively mature and successful Kenya charcoal stove program, which this report concentrates on, has been found to have a number of significant remaining problems in terms of promotion and dissemination. Thus far, the Kenya program has also been poorly documented and evaluated and has, therefore, not provided a clear model to the many programs trying to emulate its example.

Options for Regional Services for Stove Programs

While the need exists for the creation of greater regional capability in the improved stoves (household fuels conservation) area, the choice of how to institutionalize this capability is not yet clear. Several options should be considered for the development and institutional location of regional capability in the stove and household fuels area, and these are described below. In order to be most effective, an option must establish capability within an appropriate institutional structure meeting certain basic prerequisites. These prerequisites include the following:

1. Basic professional and management strength of the institution and compatibility of these household fuel activities with the current mandate and program.

2. Ability to attract and retain senior and experienced staff who are technically capable in each of the necessary specific fields.

3. Ability to develop a minimum annual volume of user demand for services to demonstrate and subsequently to satisfy, a real need for services.

4. Ability to eventually become locally or regionally self-sustaining with an increasing share of costs from revenues earned for services provided to projects or other clients.

5. Capabilities appropriate to service the region, including multiple language skills among staff, and a location with good communications and international travel connections.

The options perceived for addressing regional needs include the following:

Option 1 - Multiple Existing Specialized Institutions

Selection of existing institutions containing one or more areas of expertise corresponding to needed technical capability (i.e., stove design and testing, ceramics, market assessment, consumer surveys, respectively), in order to establish specific "centers of excellence."

Option 2 - Single Existing Institution

Build on an existing institution to establish the capability to provide technical assistance in all major fields required.

Option 3 - Create a New Institution

Design a new institution to house all of the required capability to serve the region.

Arguments For and Against

Option 1 - Multiple Existing Specialized Institutions. This approach would utilize and help build on the skills and personnel already in the region but not centrally located. Of the three options, this would be the most cost-effective means of tapping expertise and allow the choice of the best capability in particular areas. It would also eliminate the need to build expertise that may not be compatible with the existing interests or capability of an institution.

Good coordination and networking would be necessary to ensure effective delivery of decentralized support services. This option would also require some sort of centralized management and coordination. Several agencies and programs have previously attempted to "network" in the stoves area in the region, but efforts have not been adequate. They have, for example, had insufficient funding and technical capability, as opposed to networking capability (e.g., for travel, telecommunications, etc.).

Option 2 - Single Existing Institution. This option would build on a single strong existing institution and has the advantage of lower establishment costs. This option, however, has been partially tried (with KENGO and the KU-ATC) and the experience shows that it is difficult to harness institutions which have a multitude of other activities and whose staff may lack the requisite skills. Furthermore, it is difficult for an existing national institution to take on a strong regional role and give this aspect of its program adequate attention.

Existing national staffing may also not be adequate, and accepting staff from other countries to expand capability may not be administratively feasible. In addition, this additional mission may not be compatible with existing programs or may compete for the same scarce talented staff. Finally, other institutions, governments and donors must view the institution located in one of the participating countries as being committed, responsive

to their needs, objective, and effective. The likelihood of success diminishes greatly if any of these characteristics does not prevail.

Tapping existing expertise in an international NGO or private firm is another possible approach under this option or Option 1. A number of firms and persons in the region with experience in the promotion of ceramic stoves production and technical capability in stove manufacturing are now acting as technical advisers on a full or part-time basis. This includes staff of international NGOs such as CARE, as well as commercial manufacturers who also act as technical advisory staff within the region as well. Problems with reliance on an international NGO may include conflicts in priorities within a multipurpose NGO, conflicts with staff having a multitude of other responsibilities, and an understandable tendency to concentrate on one's own initiatives.

Existing improved stove manufacturers have been a source of expertise in the past as well. Manufacturers acting as stove professionals, however, are prone to place their commercial interests and pursuit of business opportunities ahead of their technical assistance functions. Furthermore, although manufacturers tend to have entrepreneurial and manufacturing skills, they do not tend to have the broader skills needed, for example, in market surveys, stove testing, stove design, and ceramics necessary for assistance to new programs.

Option 3 - Single New Institution. The option of creating a new institution offers certain benefits over the use of a single existing institution. One major attribute of this option is starting with a clean slate. This allows the design of the institution for the tasks intended. There are a number of problems with this approach, however. Start-up costs would be much higher for a new institution. There will also be a strong bias among countries against creating a new institution in another country to service (partially) one's own needs. Finally, any new institution would require a substantial amount of time to establish its skills, and there would be no guarantee that it could attract and hold the appropriate staff.

Funding

While some donors (such as the Dutch) are interested in a regional improved stoves program support facility, there are several factors that make it difficult to develop such a facility. The largest supporter of improved stoves activities in the region is the World Bank. However, World Bank stove programs are funded primarily through International Development Association (IDA) credits, rather than on a grant basis. Therefore, even with host government support, it is difficult to obtain project funds for regional activities (other than training). Furthermore, there is no obvious existing institution for housing the improved stoves/household fuels conservation facility. On the other hand, if it were decided to support the concept of multiple "centers of excellence," many potential institutions could readily be found, and entities such as international NGOs, and local or international consulting organizations could provide initial coordination, management, and financial oversight.

Conclusion. The review of the above options leads to the conclusion that while the need exists for the creation of greater regional capability in the improved stoves (household fuels conservation) area, the choice of how to institutionalize this capability is not yet clear. There are, however, many individuals with good technical and training skills to be found throughout the East and Southern African region who, with some substantial and consistent support, could form the initial capability for a regional program. *It is strongly recommended that further consideration be given to how to tap the existing expertise in the region and to build and focus this capability to meet the needs for energy conserving stove development and similar household energy conservation programs.*

IX. APPLICATION OF LESSONS LEARNED TO THE SUDAN

BACKGROUND

The Sudan Renewable Energy Project (SREP II), sponsored by A.I.D. and the Government of the Sudan, is being undertaken jointly by the Sudan Energy Research Council (ERC) of the Renewable Energy Research Institute (RERI) of Sudan, with the assistance of a U.S. contractor, Associates in Rural Development (ARD). The charcoal conservation component of this project focuses on the introduction of improved charcoal stoves. The SREP II project is the only major A.I.D. effort currently underway in Sub-Saharan Africa involving household fuel conservation and the introduction of improved stoves.

The SREP II Project follows-on SREP I which commenced in late 1983 and was implemented by the Georgia Institute of Technology through the Sudan RERI of the Sudan ERC. The SREP I Project pioneered improved charcoal stove development in the Sudan with the development of the "canun el-duga" (charcoal waste or "fines" stove), designed to utilize the fines generated during the transport of charcoal. The prototype was an all-metal stove which was fuel efficient. However, this stove was difficult to fabricate and expensive, and its primary justification (utilizing waste fines) disappeared during the project as people began to use fines in traditional stoves. Nonetheless, the laboratory and field tests (1,000 households) undertaken under SREP I laid the groundwork for a more extensive improved stoves program.

Sudanese from the ERC and CARE who have been active in the improved stoves field, have undergone training in production and stove testing in Kenya or under Kenya staff in the Sudan since 1984. Additionally, A.I.D.'s Energy Initiatives for Africa has sponsored exchanges between Kenya and the Sudan since 1986.

CARE/Sudan, with A.I.D. assistance, initiated a stoves program in 1984 to conserve energy in refugee camps in Eastern Sudan. Several hundred improved institutional stoves were fabricated during the drought. However, activities in this area came to a halt when CARE began to refocus its attentions on household stoves in Khartoum and El-Obeid. CARE introduced a modified version of the Kenya Ceramic Jiko in 1987.

The SREP II Project provides an excellent opportunity to apply the lessons learned from the Kenya Ceramic Jiko experience for three major reasons:

1. Efforts have been underway for several years to adapt Kenyan ceramic stove to the Sudan, and there have been promising results to date.

2. Charcoal is a major fuel source in the Sudan (some 95% of urban dwellers consume charcoal).

3. The economic and environmental costs of supplying charcoal are growing, and woodfuel resources are becoming more scarce.

SUDAN'S ENERGY AND ECONOMIC SITUATION

The Sudan is currently facing a series of major socio-economic and agro-ecological crises. The economy has not recovered from either the post-1979 recession or the 1984 drought. A civil war is currently being fought in the South, and that, coupled with civil war in neighboring Ethiopia and Chad, has left the country with over 1 million refugees in the North. The drought has continued unabated over much of the country, and torrential floods have recently wreaked havoc in the Central and Northern Regions of the country.

Biomass energy sources estimated to supply some 80% of total energy, the majority of which is used for households, are endangered as natural woodlands, almost entirely in the south and southeast of Northern Sudan, are being cleared at an alarming rate, primarily for mechanized agricultural production. The "Three Towns" (of Khartoum, Omdurman, and Khartoum North), have grown from a population of less than one million in the mid-1970s to perhaps 2.5 million today (swelled, in large part, by hundreds of thousands of refugees). Northern Sudan has historically always been a charcoal consumer (charcoal was used commercially and in households over 2,000 years ago in the area around and to the north of present day Khartoum). The legacy of centralized distribution (as contrasted with decentralized production) has endured to the present.

However, today's rapidly expanding population, both in urban and in commercial rural areas such as the Gezira Scheme, south of Khartoum, with its 1.5 million tenants has increased the demand for charcoal considerably over the past two decades. At least 95% of all urban households consume charcoal, and recent National Energy Administration (NEA) surveys in rural Central Sudan show that over 75% of all people utilize charcoal at least occasionally. Charcoal commands as much as 10% of low income household expenditures.

Charcoal is now supplied from up to 800 km from Khartoum (over 500 miles). It is estimated that charcoal production for Khartoum alone accounts for the clearfelling of some 8-15,000 hectares (assuming 25 cubic meters per hectare) per annum.

It is with the above factors in mind that A.I.D., the FAO, the Dutch, and other donors have attempted, over the past few years, to develop household energy conservation programs that have focused on improved charcoal stoves. However, neither supply nor

biomass conversion programs (e.g., improved charcoal production) funded over the past several years appear adequate to mitigate this situation. A combination of actions will therefore be required, including the following:

1. Increased support for better natural resource management (e.g., regulation of large-scale land clearing by mechanized means) and forestry policy reform (e.g., charcoal production taxes, transport levies, and sales licenses).

2. Increased funding for commercially viable and private sector-based woodfuel supply efforts (e.g., maximum recovery of woodfuels off land cleared for mechanized agriculture).

3. Broad-based conservation efforts designed to meet explicit targets for woodfuel savings and lower consumer fuel expenditures.

Charcoal Production, Supply, and Marketing. Charcoal production in the Sudan is perhaps as efficient as any place in Africa (conversion efficiencies have been routinely recorded in the 25-30% range).[1] Production, while decentralized, is on a large-scale and is highly organized. Likewise, transport is highly organized. These centralized depots serve as the first stages of charcoal distribution. Thousands of retailers purchase charcoal from the depots and market through small shops (kiosks) and markets throughout the Three Towns. The entire process, from production to final sales, is characterized by considerable market efficiency. Production and distribution is vertically integrated. Entry into the market is easy and capital costs are low. Therefore, the margins at each and every point are low. These factors have led to a well-developed charcoal marketing system that currently out-competes any other fuel delivery system in place. Charcoal is sold in 30-35 kg bags for LS (Sudanese Pounds) 25-35 (about $6 at official exchange rates), depending on the season and location of supplies.

The organization of the entire charcoal production and distribution system makes it possible for Government to intervene on the policy side to rationalize production in a manner that would be more ecologically sound. This, in the long term, would raise the price of charcoal (which has declined in real terms over the past decade) and encourage more household energy conservation. There is considerable room for action in this sphere and A.I.D., the World Bank, and others are assisting Government in this area.

Stove Production Systems. Khartoum's stove production system is characterized by varied production methods and a fairly centralized distribution system. Most "traditional" household stoves are made from thin metal (e.g., cooking oil tins) and are quite intricate. Sudan has a long history of metal-working, and Sudanese metalsmiths are some of the most skilled in sub-Saharan Africa. Stoves are generally produced at selling points or are taken by producers to centralized markets where other metal goods are sold. Stoves retail for LS

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[1] D.E. Earle, Report on Charcoal Production (Khartoum: SREP-ERC, 1984); and D.E. Earle, Sudan--The Economics of Wood Energy Production on Mechanized Farms (Khartoum: SREP-ERC, 1985).

10-25, depending upon the size of the stove. The most standard charcoal brazier, with a lifetime of 6 months to a year, will cost approximately LS 10.

The SREP, CARE, and the FAO all have evolved improved stoves programs over the past four years. As noted above, the SREP stove (the all-metal "canun el-duga") has basically been discontinued due to its high cost and complicated construction. CARE, on the other hand, is actively promoting its version of the KCJ. It supports a single, well-established ceramicist (Sudan also has a long history of quality ceramic production) and several metalsmiths in producing the "canun el-surour" (Sudanese "jiko"). CARE claims to have sold over 10,000 of these ceramic stoves with metal claddings since 1987. FAO is funding the production of ceramic stoves modelled on the "Thai bucket stove," primarily through the same producer with whom CARE is working.

SCOPE OF THE SREP II PROJECT

The SREP II project began with an effort to define its improved stove activity, which is intended to build on and go beyond the work done in the initial SREP project. There appear initially to be three basic questions for the project to address: first, how to restructure the stove program and carry on effective and technically sound development, testing, and dissemination of improved charcoal stoves; second, how to ensure that the project effectively addresses charcoal conservation issues and has a significant conservation and/or social impact; and third, how to ensure compatibility with plans for follow-on projects such as those planned by the World Bank. The World Bank has just completed the design of a new comprehensive Wood Energy Conservation Project which is expected to begin in mid-1989.

It appears appropriate for the SREP II project to consider not only technical issues or designing its improved stove activity, but also to reassess the market and the socio-economic and environmental context within which the program is intended to operate. The following questions are appropriate for the stove component of the project to address in its current initial planning process:

1. What does charcoal consumption portend for woodfuel resource depletion, the trend in real charcoal prices, and projected sustainability of supply?

2. What are the patterns of demand for charcoal and other fuels, and what is the potential for fuel substitution and/or conservation?

3. What is the prospective role of an improved charcoal stove program in mitigating both supply and socio-economic (fuel cost and availability) problems?

4. How should an improved stove activity be structured to reflect the characteristics of Sudan's existing stove production, marketing and materials

supply systems, income levels of the majority of the population, and energy usage patterns?

5. Would improved stoves contribute to better meeting the energy needs of refugees in the Sudan? If so, what strategy should the project pursue to assist in the procurement and production to meet this need?

The SREP II Project plans to support the widescale dissemination of the "canun el-surour" and is gearing up to assist in the production and marketing of the stove. The Sudanese KCJ, however, faces many of the quality control issues faced in Kenya, and there is as yet an imperfect understanding of the stove market and marketing systems. Metal for claddings is also less available (hence, more expensive and harder to obtain) than in Kenya. These, and other issues, require adaptations on the Kenyan experience such as

1. economizing on or eliminating metal parts;

2. developing and testing all-ceramic stoves and improvements in the traditional stove; and,

3. developing a better understanding of traditional production and marketing systems, as well as consumer preferences and ability to pay.

Even after several years of donor-assisted improved stoves activities, there is insufficient knowledge about the way producers obtain materials, organize production and distribute their wares, how retailers obtain stoves, who they sell to, and how and where consumers purchase their stoves. With this imperfect picture of the market, it is difficult to develop a good market profile that would provide producers with a clear idea of what price the market will bear, how varied the market might be, and what preferences and what range of stoves might be possible in the country. As set out in the criteria for a good stove program (above), a complete market profile is essential for successful self-sustaining production and marketing.

Further field testing is also important in the Sudan as it is needed for stove designs to reflect local cooking habits, social patterns, the local availability of materials, and, as cited above, the markets (both fuel and stoves). Field testing methods must be simple, easy to administer and easy to monitor. Criteria for judging and analyzing stove performance (in all senses) need to be in place to compare one stove to the next, one socio-economic group to another, one food preparation technique to another, and so on.

The same essentially applies to laboratory testing. Testing standards, agreed upon by all interested parties, need to be established and put in place. The National Cookstoves Network (NCN) founded in 1986, appears to be the appropriate coordinator in these activities (field and laboratory testing). The NCN is comprised of representatives of all agencies involved with improved stoves (i.e., ERC, CARE, FAO, etc.) and is chaired by a representative of the National Energy Administration (NEA).

The SREP II Project should stress the development and promotion of stoves which are acceptable to the market, which are affordably priced, and which are easily produced within

the Sudanese context (materials, labor, etc.). The objective of reducing per capita charcoal consumption is an appropriate primary criterion. However, this can only be successfully accomplished if market dynamics, consumer tastes, producers' capabilities, and traditional distribution systems are utilized. The SREP II Project should be encouraged to continue its work with CARE and other agencies to promote these objectives.

Summarized in Table IX-1 are screening requirements for the successful introduction of improved stoves from the perspectives of users, producers, retailers, Government, and donors. This summary also provides a good idea of the conditions met by the KCJ in Kenya (which explains much of the KCJ's success). Section VIII of this report provides more specific guidelines on program components, resolution of constraints, and topics of implementation that are also relevant to the Sudan.

One of the major issues that has become apparent during this review is that the time between now and the beginning of the Government-World Bank Project will need to be used judiciously to ensure that the appropriate stove technologies are well-tested, well-proven, and ready for major promotion. The Sudanese Government-World Bank Project will surely contain major elements for financing private sector activities in wood energy conservation (not only in cookstoves, but in industries and institutions as well). Those funds will be used much more effectively if markets are better understood, if technologies are better proven, and if consumers have made at least preliminary technology selection choices

CONCLUSIONS AND SUGGESTIONS FOR THE SUDAN STOVE PROGRAM

The review of the Kenya program in this report, as well as the guidelines for improved stove programs in Section VII, have direct relevance to the Sudan, but they must be carefully and thoughtfully applied. Based on a review of the Kenya experience, a brief visit to the Sudan, and a review of the Sudan situation, the following specific suggestions are offered for the Sudan program:

1. Confidence in the appropriateness of stove(s) to be introduced in terms of cost, durability, producibility, and widespread acceptability should precede large scale production or consumer promotion efforts. Additional assessment of the Sudanese stove market from the producer to consumer is essential, as are field tests of any proposed improved stoves, prior to dissemination.

2. Technology materials and dissemination methods should proceed from an understanding of local production and marketing systems and be tailored to complement these systems.

3. The development of additional improved stove models utilizing alternative materials and lower cost should proceed parallel to any promotion of the "canun el surour."

TABLE IX-1
SCREENING CRITERIA FOR STOVE INTRODUCTION

User Level:

- Stove must save fuel and expenditure on energy.
- Performs all traditional stove cooking functions well.
- Perceived as better; improves status.
- Reduces kitchen hazards, e.g., burns, smoke, etc.
- Competition keeps prices down and quality good.
- Stove is reasonably durable and reliable.

Producer Level:

- Earnings are equivalent to or greater than other uses of capital and time.
- Technology not be too complex or difficult to learn.
- Materials for construction are readily available.
- Technical assistance required can be readily made available.
- Quality can be maintained adequately to ensure purchaser satisfaction and maintain sales volume.
- Skilled labor is available and/or training requirements are feasible.
- Financial requirements are within the capability of the firm/entrepreneur, or adequate financing can be obtained.

Retailer Level:

- Stove sells rapidly and profit margins are comparable or better than current items sold.
- Quality of stove is adequate to generate no significant customer complaints or returns.
- Producers are reliable.
- Competition keeps prices low and quality good.

Implementor/Donor Level:

- Stove achieves significant energy savings on a household (or area basis).
- Achieves significant net financial benefit to households in reducing expenditures.
- Employment and income are enhanced for producers and employees.
- Government and/or other local capability is created to continue and expand program.
- Program is likely to be self-sustaining without continuing external support or subsidy.
- Cost-benefit ratio for the project meets the target, i.e. results justify the level of expenditure.

4. Given the low cost of existing stoves (roughly Ls 10-12) versus improved versions and the difficultly of converting the traditional production system into a part of the improved ceramic stoves systems, further effort should be devoted to improvements in the traditional stove, as well as an evaluation of alternative all-scrap metal stoves.

5. A low-cost all-ceramic stove appears to be another appropriate alternative for the Sudan. Such a stove will require further design, evaluation, and field test efforts before it can be judged ready for dissemination. Additional support should be obtained from the local and international sources to simplify and ensure high quality in this product.

6. Support for the promotion of private commercial production of improved stoves, whether developed through the project or otherwise, appears to be an important function for the SREP II project. Selection of firms for support (whether by the project or intermediaries such as NGOs) should be carefully and objectively carried out in line with the findings in this report regarding the prerequisites for success (see Section VIII).

7. The project would do well to support efforts in monitoring and evaluation of charcoal consumption and fuel switching before and after stove purchase, as well as in monitoring traditional and improved stove production (see Sections VII and VIII for an expanded discussion of monitoring and evaluation requirements).

8. Assistance should be provided to the ERC and the NCN, administered by the NEA, to establish uniform field testing and monitoring criteria and formats for improved stove activities in the Sudan.

8. The project should continue to closely follow the upcoming Government and the World Bank Forestry Project's "Wood Energy Conservation" component, and help ensure that the SREP II Project sets the stage for this Project.

9. The project should further evaluate fuel substitution issues (e.g., relative fuel pricing, supply, and distribution) and alternative fuel options and monitor relative fuel prices and availability over time. As noted elsewhere, relative fuel prices have a great deal to do with the ability to introduce new fuel using devices, as well as the relative desirability of these devices.

10. Standardized laboratory and kitchen testing standards should be developed and adopted through the (NCN).

ANNEXES

ANNEX 1
URBAN AND RURAL WOODFUEL USE FORECAST ASSUMPTIONS

The forecasts in Table III-1 for urban and rural households are based on household growth projections and average fuel usage rates. These estimates are derived from estimated 1980 consumption primarily from the Beijer Institute and Government of Kenya, "Kenya Fuelwood Project,"[1] and various Kenya household energy surveys,[2] and adjustments described herein. Estimated average per household charcoal consumption (adjusted for an error in Beijer Institute initial figures as explained in Table III-1) modified over time with the assumptions shown below, is applied to total households in urban and rural areas, and projected based on estimated household growth. Average consumption per household is adjusted over time based on an assumed introduction of more efficient charcoal stoves. This introduction is based on observations of trends in stove production and sales from 1983 to 1988. These trends and assumptions provide a crude but plausible and verifiable basis for projections. No sound basis exists for estimating price elasticities and for econometrically based growth projections.

Urban and rural firewood use is forecast to grow at a rate proportional to household growth. Here again average utilization per household is decreased over time due to assumed greater scarcity and accompanying conservation, and the penetration of more efficient firewood stoves. Rates are varied for urban and rural areas. The introduction of improved firewood stoves, for example, accounts for a reduction in rural firewood usage of 5.3% in 1990 and 8.6% in 2000. Such reductions are felt to be reasonable approximations to decreased average usage per household either reflecting greater scarcity and husbanding of resources (plausible given the measured differences in consumption in rural areas with different current resource levels), greater commercialization of rural firewood over time, or the introduction of improved stoves.

In the case of industry and commerce no data was available on specific conservation actions and average use per unit output. Therefore, estimated real prices and modest price elasticities were applied to introduce some moderation of the simple extrapolation of past consumption trends based on average historic growth rates.

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[1] O'Keefe, et al., Energy and Development...

[2] Central Bureau of Statistics, Rural/Urban Household..., (October-November 1978 and August 1980).

FORECAST ASSUMPTIONS

Real price increase

Charcoal	3.5%
Fuelwood	1.0%

Price elasticities

Charcoal	-0.25
Fuelwood	-0.25

(applied to industry and commerce only)

Jiko efficiency

Traditional	20%
Improved	30%

Improved jiko

Penetration:

1990	25%
2000	40%

No. of households--urban (household size 4.22)

1980	590,750
1990	1,292,200
2000	2,921,000

No. of households--rural (household size 5.98)

1980	2,370,000
1990	3,267,000
2000	4,248,000

Population growth rates

Urban--major centers	6%
Urban--minor centers	10%
Rural	2.8%

Kiln Efficiency

1990	12%
2000	18%

Kiln penetration

1990	12.5%
2000	25%

Firewood use efficiency

Traditional	12.5%
Improved	18%

Improved firewood stoves/conservation penetration:

	Urban	Rural
1990	25%	15%
2000	40%	25%

Urban charcoal use per average household per year

1990	437 kg
2000	423 kg

ANNEX 2
COMPARATIVE URBAN FUEL COST CONSIDERING DEVICE EFFICIENCY AND DEVICE COST

FUEL	ENERGY CONTENT (Mj/unit fuel	DEVICE EFFICIENCY CIENCY 1985	PRICE (kSH/UNIT fuel) 1985	PRICE PER MEGAJOULE (Ksh) 1985	COST FOR AVERAGE AGE URBAN HOUSE-HOLD'S ANNUAL COOKING ENERGY 1985 f/	DEVICE COST PER SINGLE BURNER 1985	COST FOR AVERAGE URBAN HOUSEHOLD'S ANNUAL COOKING ENERGY INCLUDING DEVICE COST 1985
WOOD							
(Wood stove)	15.5/kg 0	0.25 a/	0.55	0.04	610	20	630
	8990 /cu m	0.25	319	0.04	610	20	630
(Open fire)	15.5/kg	0.13 a/	0.55 (Urban fuel use)	0.04	1221	0	1221
CHARCOAL							
CASE A Tin	32.45 /kg	0.20 b/	1.50	0.05	994	24	1018
Sack	32.45 /kg	0.20	1.20	0.04	795	24	819
CASE B Tin	32.45 /kg	0.30 b/	1.50	0.05	663	40	703
Sack	32.45 /kg	0.30	1.20	0.04	530	40	570
PARAFFIN e/	35 /lt	0.50 a/	6.50	0.19	1597	110	1707
LPG	45.2 /kg	0.60 a/	9.20	0.20	1459	333	1791
ELECTRICITY	3.6 /kWh	0.75 a/	0.75	0.21	1194	200	1394

Annualized Service Cost for Cooking Devices
(undiscounted)

Fuel	Device Lifetime Price		Cost Per-Variable Year	Names
Wood	40	2	20	wdev
Charcoal				
Case	25	3 c/	24	cdeva
Case	80	2	40	cdevb
Paraffin	220	2	110	pdev
LPG	950	5 d/	333	ldev
Electric	700	5 g/	140	edev

a. K. Krishna Prasad, Wood-Burning Stoves (Beijer Institute, Dec. 1981), Table 8.4.
b. Stephen Joseph, et al., with the Ministry of Energy and Regional Development, Tests Performed on the Kenyan Claystove (1982).
c. Two grates at Ksh. 8/- are required per year.
d. Deposit for a 13kg LPG container is about Ksh. 950/-. This is returned upon surrender and is, therefore, costed at a 15% annual rate and added to annualized cost.
e. This is not the petrol station price which is about 30% cheaper, but reflects resale in small shops. This occurs due to scarcity.
f. Unit annual energy is taken to be equivalent to delivered energy from use of 675 kg/yr of charcoal at .20 efficiency. This is the Kenyan average urban charcoal use.
g. Included is a 2000/charge for initial residential hook-up valued at annual rate of 15%.

Source: World bank Mission, Peri-Urban Charcoal Fuelwood Study (Nov. 15, 1985). Based on a survey of fuel and device prices in Nairobi, Nakuru, Kisumu, and Mombasa, 1985.

ANNEX 3
REGRESSIONS USING CORRECTED, 1986 IMPACT ASSESSMENT DATA

Following are the regressions reported in Section 5 indicating the effect of KCJ use on charcoal consumption holding constant all other variables that might affect consumption. In both Nairobi and Kisumu, two types of regressions were run. In the first type, dummy variables were included for all stove types used by a household. In these regressions, the dummy variables may equal one for more than one stove type. In the second type of regression, dummy variables were included for the stove used most. In these regressions, the dummy variables take the value one for only one stove type.

Initial sample sizes were 599 for Nairobi and 489 for Kisumu. Missing observations on certain variables reduced sample sizes to 553-556 in Nairobi (depending on the regression) and to 411 in Kisumu. The primary variables with such missing observations were numbers of adults and/or children in the family, number of meals cooked per day, amount of charcoal used, and/or price paid for charcoal.

Table A3-1 contains the definitions of the variables for the following regressions.

TABLE A3-1
DEFINITIONS OF VARIABLES USED IN REGRESSION ANALYSES

Variable	Definition
ADULT	Number of persons over age 14 or who eat in household
C	Constant term
CHARPD	Charcoal used per household per day in kg (dependent variable)
CHILD	Number of persons under age 14 who eat in household
ELECCK	Dummy variable: uses an electric cooker
FWFIRE	Dummy variable: uses a three-stone fire
GASCKR	Dummy variable: uses a gas (LPG) cooker
HIGH	Dummy variable: in the high income group
KCJ	Dummy variable: uses a Kenya Ceramic Jiko (improved stove)
KERSV	Dummy variable: uses a kerosene stove
MEALS	Number of meals prepared in the household per day
MEDIUM	Dummy variable: in the medium income group
MELECC	Dummy variable: most often used stove is an electric cooker
MFWFIR	Dummy variable: most often used stove is a three stone fire
MGASCK	Dummy variable: most often used stove is a gas (LPG) cooker
MKERSV	Dummy variable: most often used stove is a kerosene stove
MKCJ	Dummy variable: most often used stove is a Kenya Ceramic Jiko
OTHRFU	Dummy variable: uses charcoal for a noncooking, non-space heating, non-water warming purpose
PRICE	Amount paid for charcoal in KSh per kg
SPHEAT	Dummy variable: uses charcoal for space heating
TMS	Dummy variable: uses the traditional metal charcoal stove
WRMWTR	Dummy variable: uses charcoal to warm water

The number of meals cooked per day is omitted from the Nairobi regressions. In a regression equation that included this variable, its coefficient was insignificant at the 0.10 level in a one-tailed test. It was dropped because a significant proportion of the observations with missing values on meals cooked per day were KCJ-using households. When these observations were excluded in order to include the meals per day variable, the KCJ coefficient became insignificant, but unjustifiably so because of the excluded observations.

TABLE A3-2
REGRESSION FOR NAIROBI, ALL STOVE TYPES USED BY HOUSEHOLD INCLUDED IN EQUATION

Ordinary Least Squares // Dependent Variable is CHARPD
Date: 9-20-1988 / Time: 10:28
SMPL range: 1 - 106 108 - 557
Number of observations: 556

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.4552213	0.4752764	5.1658808	0.000
CHILD	0.2933367	0.0326545	8.9830419	0.000
ADULT	0.2491264	0.0455426	5.4701884	0.000
GASCKR	-0.2497898	0.2304031	-1.0841426	0.278
KERSV	-0.5212448	0.1616553	-3.2244214	0.001
TMS	0.0003358	0.2789238	0.0012040	0.999
KCJ	-0.4493750	0.2543596	-1.7666918	0.077
ELECCK	-1.3081293	0.6652837	-1.9662730	0.049
FWFIRE	0.3748175	0.2946709	1.2719869	0.203
WRMWTR	0.3123936	0.1790351	1.7448738	0.081
SPHEAT	0.0793523	0.1501482	0.5284930	0.597
OTHRFU	-1.3914984	1.7050616	-0.8160986	0.414
PRICE	-0.6925686	0.1385206	-4.9997531	0.000
MEDIUM	0.1789305	0.1860847	0.9615541	0.336
HIGH	-0.6703057	0.4827708	-1.3884553	0.165

R-squared	0.321586	Mean of dependent var	2.618129
Adjusted R-squared	0.304030	S.D. of dependent var	2.029626
S.E. of regression	1.693212	Sum of squared resid	1551.029
Durbin-Watson stat	2.086055	F-statistic	18.31771
Log likelihood	-1074.132		

TABLE A3-3
REGRESSION FOR NAIROBI, STOVE TYPE USED MOST BY HOUSEHOLD INCLUDED IN EQUATION

Ordinary Least Squares // Dependent Variable is CHARPD
Date: 9-20-1988 / Time: 15:42
SMPL range: 1 - 13 15 - 106 108 - 205
207 - 211 213 - 557
Number of observations: 553

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.5701931	0.3501784	7.3396679	0.000
CHILD	0 2668155	0.0314696	8.4785206	0.000
ADULT	0.2253251	0.0447904	5.0306573	0.000
MGASCK	-1.2455785	0.3239048	-3.8455076	0.000
MKERSV	-1.0394787	0.1877678	-5.5359788	0.000
MKCJ	-0.6567776	0.2251688	-2.9168236	0.004
MELECC	-1.2363465	0.7641126	-1.6180161	0.106
MFWFIR	-0.4915725	0.9790676	-0.5020823	0.616
WRMWTR	0.1096863	0.1812679	0.6051064	0.545
SPHEAT	0.1521507	0.1455724	1.0451885	0.296
OTHRFU	-1.2939851	1.6705605	-0.7745814	0.439
PRICE	-0.6442986	0.1367271	-4.7122951	0.000
MEDIUM	0.2399378	0.1711437	1.4019673	0.161
HIGH	-0.5526655	0.4571792	-1.2088595	0.227

R-squared	0.344602	Mean of dependent var	2.615986
Adjusted R-squared	0.328794	S.D. of dependent var	2.029624
S.E. of regression	1.662813	Sum of squared resid	1490.307
Durbin-Watson stat	2.128006	F-statistic	21.80003
Log likelihood	-1058.789		

TABLE A3-4
REGRESSION FOR KISUMU, ALL STOVE TYPES USED BY HOUSEHOLD INCLUDED IN EQUATION

Ordinary Least Squares // Dependent Variable is CHARPD
Date: 9-21-1988 / Time: 14:05
SMPL range: 1 - 411
Number of observations: 411

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	2.1567446	1.1604437	1.8585518	0.063
CHILD	0.2262748	0.0444717	5.0880646	0.000
ADULT	0.2511417	0.0709083	3.5417842	0.000
GASCKR	-1.1658018	0.4369197	-2.6682289	0.008
KERSV	0.0806817	0.2066515	0.3904239	0.696
TMS	0.6407510	0.7091481	0.9035504	0.366
KCJ	-0.5146255	0.57349 6	-0.8973550	0.370
FWFIRE	-0.4523990	0.4546497	-0.9950496	0.320
WRMWTR	-0.2045427	0.2765765	-0.7395518	0.460
SPHEAT	-0.2900596	0.6185714	-0.4689186	0.639
OTHRFU	-1.5182999	0.9310718	-1.6307013	0.103
PRICE	-1.7579226	0.4385224	-4.0087407	0.000
MEDIUM	0.6399058	0.2668493	2.3980049	0.016
HIGH	-1.9178917	1.9995133	-0.9591793	0.337
MEALS	0.4610414	0.1985903	2.3215709	0.020

R-squared	0.177008	Mean of dependent var	3.054453
Adjusted R-squared	0.147912	S.D. of dependent var	2.157116
S.E. of regression	1.991203	Sum of squared resid	1570.097
Durbin-Watson stat	1.709096	F-statistic	6.083650
Log likelihood	-858.6152		

TABLE A3-5
REGRESSION FOR KISUMU, STOVE TYPE USED MOST BY HOUSEHOLD INCLUDED IN EQUATION

Ordinary Least Squares // Dependent Variable is CHARPD
Date: 9-21-1988 / Time: 14:13
SMPL range: 1 - 411
Number of observations: 411

VARIABLE	COEFFICIENT	STD. ERROR	T-STAT.	2-TAIL SIG.
C	3.1154155	0.8917228	3.4937041	0.000
CHILD	0.2026842	0.0437394	4.6339063	0.000
ADULT	0.2442535	0.0707005	3.4561763	0.001
MGASCK	-1.8537978	0.6080101	-3.0489587	0.002
MKERSV	-0.6321894	0.3493021	-1.8098642	0.070
MKCJ	-1.1937215	0.4725823	-2.5259545	0.012
MFWFIR	-0.7287632	0.6473716	-1.1257263	0.260
WRMWTR	-0.1775760	0.2741039	-0.6478418	0.517
SPHEAT	-0.2610282	0.6128175	-0.4259476	0.670
OTHRFU	1.4795313	0.9309956	-1.5891926	0.112
PRICE	-1.7226796	0.4353648	-3.9568642	0.000
MEDIUM	0.5283609	0.2516058	2.0999550	0.036
HIGH	-1.9159636	1.9881247	-0.9637039	0.335
MEALS	0.3916284	0.1931378	2.0277149	0.043

R-squared	0.182357	Mean of dependent var	3.054453
Adjusted R-squared	0.155583	S.D. of dependent var	2.157116
S.E. of regression	1.982221	Sum of squared resid	1559.892
Durbin-Watson stat	1.713146	F-statistic	6.810919
Log likelihood	-857.2752		

ANNEX 4
WORK PLAN FOR ASSESSING IMPROVED STOVE MARKET PENETRATION AND ESTIMATED FUEL SAVINGS

CONCEPTUAL ASPECTS

In order to make a market penetration estimate, market penetration must first be defined. At least three different concepts can be meant by this term: a) the percentage of all charcoal stoves sold in a given time period that the KCJ represents; b) the percentage of households that own and/or use a charcoal stove that use a KCJ; or c) the path by which the KCJ has disseminated from its primary initial point of manufacture and sale, Nairobi, to cities and towns outside of Nairobi throughout the more populated areas of Kenya.

Obviously, the first two notions of market penetration can be quantified and would lead to similar numerical estimates in a given geographic location. They will diverge to the extent that households own and/or use more than one type of charcoal stove and to the extent that more than one household shares the use of a KCJ, a practice in some poorer neighborhoods. The third notion of market penetration cannot be quantified, but rather requires description of how the KCJ has spread from Nairobi--whether first into nearby cities and towns and then gradually into farther localities, or by leaps and bounds from Nairobi into towns, some more distant than others. If the latter, what are the characteristics of the towns into which the KCJ spread first? In either case, by what mechanisms has it spread: Has it been by manufacturing being set up in cities and towns for local sale; has it been purchase by local merchants from Nairobi; or has it been through trade and/or middlemen who have peddled the stove in outlying areas?

Another aspect to determining the penetration of the KCJ is that there are two classes of cities and towns where the KCJ may be found: those in which we know the KCJ is sold and those in which no information exists about whether the KCJ has entered the stove market. These differences in prior knowledge will affect the design of data gathering.

DATA GATHERING

Surveys/Questionnaires

Data to determine stove penetration can be gathered by two types of survey: a reconnaissance of towns where it is not known whether the KCJ is sold and a household survey in the towns where it has been determined that the KCJ is used.

In the reconnaissance, the first type of survey, surveyors will be assigned towns to which they will travel. They will move about a town, inquiring in several shops and market places as to whether the KCJ is sold anywhere in town, the length of time spent in such inquiry depending on the size of the town. As soon as a reasonable determination is made

that no KCJs are present in a town, the surveyor will move on to his/her next destination. If, on the other hand, KCJs are located in town, the surveyor will ask only five to seven questions of the retailer or artisan selling the stoves in order to economize on time:

If a retailer:

1) Where was the stove manufactured?
2) From whom did you purchase the stove (manufacturer, trader, etc.)?
3) If a middleman of some type, do you know the chain through which that person obtained the stove? If yes, how?
4) What price did you pay for it?
5) At what price will you sell it?

If an artisan:

1) What is the source of you liner?
2) What is the source of your cladding?
3) What is the source of your vermiculite and cement insulation?
4) What do you pay for liners?
5) What do you pay for claddings?
6) What do you pay for vermiculite and cement per stove?
7) At what price will you sell the stove?

After the reconnaissance, a list of towns where KCJ use has been newly ascertained will be compiled and added to a list of towns where KCJ use was previously known by the initiators of the study.

To determine the penetration rate of the KCJ in cities and towns where KCJ use has been determined to exist, a one-page questionnaire will be used to survey households. A suggested survey form is at the end of this Annex. The interview is expected to take no longer than 15 minutes. The sample size can be statistically determined, based upon government population statistics and the desired margin of error.

Sampling Technique

For the reconnaissance of towns where KCJ use is unknown, the following guidelines may be used. There are about sixty cities and towns in Kenya with population of 5,000 or more. Towns with smaller populations and rural areas use insignificant amounts of charcoal. These 60 towns will be classified into four categories on the basis of population. Then they will be identified as towns where stove use is known or unknown. If possible, all towns in which KCJ use is unknown should be included in the reconnaissance. If this is not possible due to budget constraints, a representative sample of these towns--representing full ranges of population size, ethnicity, climate, and geographic location--should be reconnoitered.

The household survey should also include cities and towns from all four population categories, and ensure full variation in ethnicity, location, and climate. Cities in the top two

categories, Nairobi and second tier cities, might be subdivided into sampling districts based on neighborhoods of fairly homogeneous socioeconomic groups. If possible, the sample frames of the Central Bureau of Statistics (CBS) should be used. Within each of these neighborhoods (sample frames), households should be chosen by random sampling. Sample frames should include adequate representation of at least three income groups, low, medium, and high.

Table A4-1 indicates a hypothetical breakdown illustrating the procedure for choosing cities for the reconnaissance and household surveys.

TABLE A4-1
CHOOSING CITIES AND TOWNS TO INCLUDE IN PENETRATION RATE RECONNAISSANCE AND HOUSEHOLD SURVEYS
(Hypothetical Data)

City/Town Category	No. of Cities/Towns in Kenya	No. Where Stove Use Is Known	No. Included in Household Survey	No. Where Stove Use Is Unknown	No. included in reconnais-sance
1	1	1	1	0	0
2	4	4	4	0	0
3	12	6	4	6	4
4	43	15	8	28	15
Totals	60	26	17	34	19

DATA COMPILATION AND ANALYSIS

Numerical data can be compiled daily as they are received from the field in a dBASE III database or a Lotus 1-2-3 spreadsheet file. This not only will facilitate quick analysis, but will insure data are checked as they are gathered and allow return to households where anomalies are found.

Qualitative assessment of the manner in which the KCJ has penetrated markets, the third definition of penetration given above, should be conducted primarily by a Kenyan familiar with local trade patterns, business practices, and geography.

KCJ PENETRATION AND CHARCOAL SAVINGS QUESTIONNAIRE

Interviewer _____ Date _____

Type of Stove	Check if Owned	Price of Stove	Date of Stove Purchase (Mo/Yr)	Location of Stove Purchase	Freq. of Fuel Purchase (Days)	No. Units of Fuel Purchase	Unit of Fuel Purchase*	Price of Fuel per Unit	Meals Cooked w/ Stove				No. Times Used per Week
									B	L	D	T	
TMS	1	6	8	10	12	17	22	27	32	33	34	35	52
KCJ	2	7	9	11	13	18	23	28	36	37	38	39	53
Paraffin	3	xxxxxxx xxxxxxx xxxxxxx xxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	14	19	24	29	40	41	42	43	54
LPG	4	xxxxxxx xxxxxxx xxxxxxx xxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	15	20	25	30	44	45	46	47	55
Electric	5	xxxxxxx xxxxxxx xxxxxxx xxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx xxxxxxxxxx	16	21	26	31	48	49	50	51	56

57. Respondent Residence Locality _____

58. Adults in Household _____ 59. Children 0-2 Yrs _____ 60. Children 2-14 Yrs _____

61. Jobs held by household members _____

62. Education, Male Head of Household: (1) No formal educ. (2) primary (3) secondary (4) high school (5) university

63. Education, Female Head of Household: (1) No formal educ. (2) primary (3) secondary (4) high school (5) university

64. Jobs held by household members _____

65. Household income (monthly) _____

66. Ethnicity _____

Enumerator complete by observation:

67. Household income group: (1) Low (2) Medium (3) High

ANNEX 5
MARKETING THE KENYA CERAMIC JIKO

The marketing process involves determining the demand for a good or service and then designing a process to create product awareness, a desire to buy, and the matching system of supply. The success of any marketing system is determined by the combination of so-called marketing "ingredients," that is, product attributes, pricing, distribution, and promotion.

Product Attributes. Based on interviews conducted for this report, the following product attributes appeared most important to prospective customers:

1. Savings in charcoal use, durability of the stoves due to ceramic liners and heavier metal, and less danger of burns.

2. Quality of the product in terms of the construction of the metal cladding and the attractiveness of the finish, construction of the ceramic liners, and the quality of the finished, assembled product.

3. Availability for purchase, convenience of after-sales service, and sellers' guarantees.

The KCJ, while generally attractive to the customer and selling readily, would be more attractive if there were standardized quality or formal quality control and greater consumer information on selection and use. Consumers also had inadequate knowledge on availability of stove repairability.

The review of the product awareness and characteristics supports the need for continued monitoring and evaluation to resolve problems that may arise with consumer awareness or stove durability.

PRICING

The main objectives of the producers' pricing strategy for the KCJ were maximizing profits, improving a share of the market, and responding to competition. The pricing of the KCJ has been characterized by three elements: first, high initial prices caused by market domination by a few producers; second, a high degree of price volatility as the product matured and competition occurred among producers; and third, price variability due to the prevalence of negotiation at all levels of the marketing system.

High Initial Prices. In its initial introductory phase, producers selling completed stoves appeared to capitalize on the novelty and energy conservation attributes of the stove and sold it at higher prices than necessary to cover costs plus what would be considered a

reasonable profit in a more competitive or mature market. This permitted producers both a significant return on their original investments, as well as compensation for their original risk and initiative in introducing the KCJ. High initial prices, however, also limited the market to higher and middle income households. High profits also stimulated additional producers to enter the market.

Price Competition. The second price phase for the KCJ, which continues today, involves vigorous and dramatic price wars between major producers. The motivation behind these price wars appears to be the desire to dominate the market, as the more well-financed producers attempt to drive others from the market. This price volatility has significantly affected producer profits. While such price reductions offer some short-term benefits to consumers, they also limit new investment and expansion in production.

Strong price competition is fostered by the centralization of the Nairobi market and sales for up-country markets around Shauri Moyo in Nairobi. Other stove production sites and markets in Nairobi and other towns are much more dispersed and fragmented. Selling through the central market (Shauri Moyo), either for local redistribution and sale or for export to other parts of the country via the intercity transport system (whose main depot neighboring Shauri Moyo), is less costly and much easier than other alternatives. Nonetheless, as market estimates in Section III indicate, the total market for stoves not based on Nairobi consumers or production is very large and, at this time, appears under exploited.

Producers interviewed are increasingly focusing on these other non-Nairobi markets, but are finding that such markets require large commitments of scarce management time, as well as higher transport expenditures to exploit. At the same time, these areas offer the opportunity for much higher margins due to the lack of competition and the novelty of the stove. It was found in informal surveys that while the retail price of the KCJ is somewhat more than twice the price of the TMS in Nairobi (about Ksh. 80/-), in outlying areas such as Nakuru and Kisumu, the KCJ may cost three times as much as a TMS (about Ksh. 120/).

Substantial effort by producers has gone into the identification of small non-Nairobi market outlets and the establishment of distribution systems. Effective use of the local bus and other transport systems, for example, has been important to distribution, allowing distributors or salespersons to operate without their own transport and drop stoves at shops adjacent to bus depots.

Negotiation. Another important aspect of the pricing system has been negotiation at all levels. For example, negotiated prices are the rule in the purchase of metal claddings by liner producers, in the sale of liners by producers to assemblers, and by stove salespersons and at retail outlets. This flexibility has been beneficial to the seller in getting the best price at each level, but has a number of adverse impacts on the consumer. These include relatively higher margins and prices where competition is weak and/or few stoves are available, and arbitrary variation in prices (not tied to stove quality) both of which discourage purchase.

Options to Rationalize Pricing. Several reactions to the above findings on pricing appear appropriate. First, better consumer information is needed to help consumers in the selection of the better quality stoves, extension of stove lifetime, and help in using less fuel. Second, more promotional activities, particularly on the benefits of the KCJ stove, should be undertaken to inform lower income households about the potential for reduced expenditure on charcoal, greater relative durability of the KCJ, and other benefits.

It is also important in order to moderate prices outside Nairobi to stimulate decentralization of the production to markets in other cities such as Nakuru, Eldoret, Nyeri, and other urban centers. This strategy is constrained by the availability of metal scrap, the availability of ceramic liners, either from central sources or from appropriate areas nearby, and the availability of artisans with basic skills in producing KCJ claddings and assembling the stoves. It will also be important to stimulate more demand for the product in other areas to justify the investment in additional production.

PROMOTION

Through product promotion, consumers are informed about the product and may be persuaded to buy the product. Sales promotion for the KCJ may involve

1. producer direct-selling or use of sales staff;

2. consumer demonstrations;

3. trade promotions such as advertising and display at trade shows (exhibitions);

4. publicity through the mass media such as newspapers, radio, magazines and television programs; and

5. promotional credit offered to sales persons, distributors or retailers.

Based on an informal producer and marketing system survey, it is apparent that there has been very limited Government or NGO promotion of the KCJ. Government participation in the promotion of the KCJ through the Ministry of Energy has involved

1. production of brochures and display of posters at the Agricultural Society of Kenya (A.S.K.) Agricultural Shows;

2. demonstrations at agricultural shows; and

3. training of artisans at Agro-Forestry Energy Centers (six in number) to try and stimulate production.

Promotion of the KCJ by NGOs concerned with improved stoves has also been minimal. One of the more active NGOs, KENGO, has periodically prepared and distributed posters, conducted some market and other public demonstrations, and used radio and television program advertisement.

Producers and distribution intermediaries have primarily relied on direct salesmanship. The use of promotional credit, advertisement, demonstration, and exhibition of improved stoves has been minimal. There has been an almost complete lack of producer promotion through advertising and demonstration. This has been due to a fear of creating a demand for competitors' products since there is no well-established brand identification.

Information to consumers about the KCJ has been provided more by word of mouth, testimony of neighbors who have bought the stove, displays in market stalls and at production sites, and simply availability in shops and supermarkets. Radio, television, and newspaper publicity has been helpful, but has reached a relatively small number of the urban population. Government promotion materials and training of producers have also had only a minor impact.

Options to Promote the KCJ. There are a number of promotional vehicles which would be appropriate to stimulate the KCJ market. These include

1. radio programs (particularly immediately after the news bulletins);

2. advertisements and publicity features in daily newspapers and rural vernacular papers which reach a large target audience;

3. demonstrations on the product, particularly in urban markets;

4. dissemination of product promotion materials, including materials containing guidelines on use and selection;

5. education of opinion leaders, such as teachers, businessmen, and church leaders, which could in turn assist in informing their constituencies about the KCJ; and

6. targeting firms employing large numbers of people as vehicles to reach their employees, especially by offering credit against future salary deductions to finance stove purchases.

DISTRIBUTION

The initial distribution of the KCJ within Nairobi was through salesmen carrying one or two stoves through the residential areas and selling to households, eventually earning a commission from the producers. Stoves are also displayed at the assembly sites where ultimate consumers or middlemen go to buy them. KCJ production centers are either within or near a market, with other products that consumers buy from the same market segment. The informal distribution system continues today with salesmen pushing carts with larger numbers of stoves to residential areas or negotiate prices and sell directly to stall or shop owners.

Currently, salesmen buy stoves from the producers outright at wholesale prices and retail to the households or sell to retailers or markets in town, with their profit based on the price they can negotiate with retailers.

Over the past several years, the KCJ and KCJ parts distribution channels have developed into several effective patterns:

1. Assembled stoves are sold by metal cladding manufacturers and stove assemblers directly to ultimate consumers at markets.

2. Assembled stoves move from assemblers directly to wholesalers and retailers and thence to ultimate consumers.

3. Producers of ceramic liners and complete stoves market directly to owners of shops, stalls, and managers of supermarkets.

4. Salesmen are employed by producers and paid a commission to transport and market stoves to major towns.

5. Producers establish their own stalls in various markets where they display and sell finished products or ceramic liners.

6. In towns without established supply links, small-scale informal traders travel to Nairobi's Shauri-Moyo market to purchase KCJ stoves to take back to their areas.

Various constraints have arisen in product distribution which are worth mentioning. These include producers trying to offer credit facilities to retail middlemen and later discontinuing this practice due to loss of trust in these middlemen and the high cost of distributing stoves, and then later returning to collect the money. The unavailability of sufficient regional KCJ production and the inconvenience of using public transport for Nairobi area producers, for either finished products or ceramic liners for shipment to distant markets, have been significant restraining factors. Such shipment also requires more complex and costly handling, storage, and intermediary involvement.

Options to Improve Distribution. One way to improve distribution is to decentralize the assembly of the KCJ to other urban centers where the metal cladding materials are available or where the entire stove can be manufactured. This would help to cut down on breakages of finished products through transportation, particularly for the ceramic liners. In addition, decentralized production would cut costs of transportation, create more convenient sites for replacements of parts and any repairs, and also make stoves available at additional sites, thus stimulating market expansion. Decentralization of production to non-Nairobi urban centers could also expand the participation of local informal sector artisans with lower production and overhead costs to help keep the prices of final products affordable.

Additional discussion of the advantages and disadvantages of decentralized production appears in Section VI.

ANNEX 6
HEALTH EFFECTS OF BIOMASS COOKING AND HEATING

Attention is increasingly being given to the health impacts of emissions from biomass cooking and heating fuels. These emissions are recognized to be an important contributing factor to the high level of respiratory infections and chronic lung disease in developing countries.

The above health problems appear to be much more important for those directly using wood or other biomass rather than charcoal. Traditional charcoal manufacturing results in a reduction of the volatile content of wood by about 70%. Most of the particulate and other hydrocarbon emissions from wood are released in this process. However, because charcoal emits CO without accompanying smoke, indoor levels of CO in charcoal use can be increased to dangerous levels. In well-ventilated situations charcoal stoves are safe, but where experience is limited and ventilation is inadequate, safety is a serious concern.[1] What evidence is available regarding the effects on CO emissions from the KCJ indicate that levels may be reduced on the order of 20% or more.

Improvements in wood stoves which may decrease their characteristically high levels of emissions into the home include: a) incorporation of a flue or other method of guiding smoke outside, b) increasing efficiency to reduce emissions, and c) utilization of alternative fuels and stoves to reduce emissions.

Programs to introduce wood stoves aimed primarily at saving wood and halting deforestation have been seriously questioned both from the standpoint of implementation effectiveness and for their potential for reducing wood consumption. The evidence to date on health effects, however, indicates additional prospective benefits for wood stove programs. However, the question of how to effectively implement such programs remains an open one.

This report on the KCJ experience sheds some light on wood stove implementation issues, first, because it addresses a key substitute for fuelwood, and second, because it helps to identify the criteria and methods by which improved stoves may be successfully introduced.

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[1] Kirk Smith, ed., Biofuels, Air Pollution, and Health--A Global Review (New York: Plenum Press, 1987), p. 323.

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