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KENYA

RENEWABLE ENERGY DEVELOPMENT PROJECT

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RENEWABLE ENERGY DEVELOPMENT PROJECT

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KENYA RENEWABLE ENERGY DEVELOPMENT PROJECT

I. SUMMARY AND RECOMMENDATIONS

A. Recommendations

Authorization of a grant for the period September 1980-September 1984, for a Renewable Energy Development Project subject to waivers and approvals for the following:

- A sole-source contract with the SUNY StonyBrook Institute for Energy Research to provide the AL-EDIS energy assessment system and related hardward and software, as AID's portion of funding for the MOE/ Beijer Institute Fuelwood Cycle Planning Project.

- A sole-source contract to the Beijer Institute (a non-U.S. contractor) to provide the Ministry of Energy (MOE) with Fuelwood/Agroforestry Demonstration Center implementation planning assistance.

- Purchase of the following commodities from non-U.S. sources: one Land Rover assembled in Kenya, seeds of tree genera or species unavailable in the U.S., selected non-U.S. energy publications for the Energy Data Bank and Library, and miscellaneous consumable materials and supplies.

- Provision of up to $25,000 in participant training in other countries in Africa.

The recommended AID grant is to be allocated for disbursement through the following implementation organizations:

- Ministry of Energy (as GOK responsible organization for Project):

- SUNY StonyBrook Institute of Energy Research (for AL-EDIS and related assistance to Beijer project):

- Beijer Institute/Clark University (for fuelwood/agroforestry implementation planning related to MOE/Beijer fuelwood planning project):

- Competitively let MOE contract (for long-term experts, short-term consultants and related equipment and expenses):

- Monitoring and Evaluation (contracts):

B. Project Summary

The project proposes to:

- Help identify and implement measures to increase the efficiency of conversion and end use of petroleum fuels, as a means of reducing balance of payments deficits and easing constraints on Kenyan economic growth;

- Provide the basis for the greatly expanded afforestation, improved forest management, and improved efficiency of wood/charcoal use necessary to prevent further serious deforestation and consequent loss of valuable soil and other resources;

- Stimulate development and dissemination of simple, low-cost renewable energy technologies meeting basic needs of the urban and rural poor; and

- Support the development of other promising renewable energy technologies which could substitute for scarce petroleum or wood fuels.

More specifically, the project will provide the following assistance:

(1) Initial Planning and Surveys: As support to the MOE/Beijer Institute Fuelwood Cycle Planning Project, provide a computer terminal, software and training support, and energy information experts necessary to install, test, and use a simplified version of the "AL-EDIS" energy assessment system developed by the SUNY StonyBrook Institute for Energy Research. Also, provide a long-term energy planner/energy conservation expert, supplemented by short-term consultants, to help install energy information systems and develop and implement national policies and programs to use wood and petroleum-based fuels more efficiently, stimulate ecologically appropriate expansion of production of wood fuels, and promote improved management of the country's forest resources.

(2) Institutional Development: Provide four long-term experts--in afforestation/forest management, agroforestry, cookstoves and charcoal production, and rural renewable energy applications--and short-term consultants and supporting materials and equipment to furnish technical and training/curriculum development assistance to government and non-government organizations. These long-term experts and consultants will be available through the MOE to help appropriate GOK Ministries identify and evaluate potential renewable energy applications, improve the technical grounding and awareness of appropriate field extension workers and organizations, and assist in implementing individual programs or projects.

(3) Applied Research and Demonstration: Help establish a network of nursery, species research, and fuelwood/agroforestry demonstration and extension centers in Kenya's major ecological centers. Such centers, to be based around existing GOK nurseries will be used to identify ecologically suitable species, provide seeds or seedlings and extension advice to individuals or groups promoting tree-planting, and demonstrate and disseminate forest management and agroforestry techniques appropriate to the region. Emphasis will be placed on integration of predominantly multi-purpose trees into crop or livestock-raising systems in ways which not only provide fuelwood and other useful wood products but also improve the micro-ecology of the area.

Also, provide consulting assistance and initial capital for the establishment, within the Ministry of Energy, of an Energy Development Fund. The Fund will (1) provide loans or grants up to $75,000 on a cost-sharing basis, to non-government organizations implementing generic afforestation, agroforestry, wood/charcoal cookstoves, or other renewable energy demonstration and extension programs; and (2) provide loans or grants up to $15,000, on a cost-sharing basis to government or non-government organizations to implement specific renewable energy demonstration projects.

(4) Monitoring and Evaluation: Use the long-term experts to survey and assess existing conditions, including current projects and activity. In the case of forest resources, work with the Beijer project to use existing Remote Sensing Center, Geosurvey and Survey of Kenya data supplemented by ground checks to estimate both present resources and recent deforestation rates by region. Throughout the Project, use long-term experts to monitor planning, demonstration, and extension activity and results and prepare annual reports on project results. Conduct a mid-term and final evaluation of the Project, to include assessment of forest resources and deforestation trends, analysis of the impact and efficacy of alternative demonstration and extension approaches, detailed evaluation of the fuelwood/agroforestry centers and assessment of both the Energy Development Fund and specific programs and projects supported through the Fund.

C. Summary Findings

The project analysis finds that the project is consistent with AID policy and program objectives and meets the design criteria outlined in the PID and subsequent PID Review. The project is appropriate to Kenyan environmental and sociological characteristics and is consistent with

Kenya's development objectives. Although difficult to quantify, the project will yield positive net economic benefits, primarily by reducing oil imports, thereby avoiding increased balance of payments deficits, and by slowing the present severe degradation of scarce agricultural lands due to deforestation. The project will also benefit the urban and rural poor directly by, for example, providing low or no-cost devices to economize on use of wood or charcoal in cooking and domestic heating.

Implementation arrangements are adequate and appropriate to the project. The project takes into account that the Ministry of Energy is new and presently understaffed, that other GOK Ministries or non-governmental organizations already have ongoing operations in many areas relating to renewable energy, and that a number of other donors plan to support various energy planning or renewable energy activities through the Ministry of Energy or other Ministries. The project is intended to complement other donor's activities, to the extent these are known; to use the existing capabilities of other GOK Ministries or of non-governmental organizations wherever possible; and at the same time to help develop the capacity of the Ministry of Energy to plan and, through other organizations, to guide the implementation of appropriate energy policies and programs.

Project implementation depends upon a number of factors -- particularly the scope and timing of other donor's activities, selection of specific sites and operating organizations for each of the proposed fuelwood/agroforestry centers, and GOK fuelwood policies adopted as a result of the Beijer Fuelwood Planning Project -- which currently are uncertain. The proposed implementation approach provides that one of the first tasks of the long-term experts will be to prepare, in conjunction with the Ministry of Energy, more detailed implementation plans.

The project meets all applicable statutory criteria.

II. PROJECT DESCRIPTION

A. Kenya National Energy Problems/Needs

Kenya currently faces three particularly serious energy related problems.

(1) Oil Imports:

The projected growth in Kenya's annual oil import bill will lead to ever-increasing balance of payments deficits unless corrective action is taken. Such oil import costs are likely to continue to be accompanied by weak developed country demand for Kenya's primary exports, increased costs of imports of manufactures and intermediate goods, and high costs of international borrowing -- themselves attributable in part to higher oil prices.

Rising balance of payments deficits already have contributed to a drop in capital available for domestic savings and investment. At the same time, due to higher costs of imported capital equipment, more capital investment now is required to achieve any given increase in Gross National Product. A direct mathematical relationship between the reduced savings rate, higher capital-output ratio, and GNP (admittedly an oversimplification) would imply a more than one-third reduction in the annual GNP growth rate. Infact there has been a greater than one-third reduction since 1973.

The situation is expected to worsen. Due largely to a roughly 60% increase in net oil import costs (oil import costs less revenues from exports of petroleum products from the Mombasa refinery) and to continued increases in the costs of imports of manufactures, the projected 1980 balance of payments deficit on current account is expected to rise to at least K£212 million, or fully 72% of Kenya's domestic savings in 1979.

Largely as a result of escalating oil import costs, the Government of Kenya recently altered its Fourth National Development Plan (1979-80 to 1982-83) targets. It roughly doubled the projected balance of payments deficit and lowered the target average annual GNP growth rate from 6.3% to 5.4% (roughly 15% reduction, which would appear optimistic). It implied that the annual employment growth rate would fall to well below the rate of population growth and that Government per capita development and social services expenditures would decline. The Fiscal 1980/81 budget incorporates targets even lower than those of the revised Development Plan.

The country has no proven fossil fuel reserves and limited ability to substitute hydro or geothermal electric power for oil. The scope for wholesale use of biomass to produce ethanol or methanol is limited by capital requirements and by the need to use available productive land for food production. The ability to boost exports dramatically to offset oil import costs is constrained by the lack of additional agricultural land and by the industrial sector's current import-substitution orientation. Accelerated substitution of fuelwood for petroleum products is likely to have very serious consequences for the ecology and for agricultural productivity.

In short, Kenya appears to have very limited short-term options in dealing with its energy cost problems. It can secure additional external financial assistance, particularly from oil-exporting nations (which it has done very effectively); and it can increase the efficiency of conversion and end-use of energy in general and of petroleum products in particular.

(2) Wood Supply-Demand Imbalance:

Current wood consumption for firewood or conversion to charcoal appears to exceed the rate of replenishment of Kenya's forest resources -- and the situation is likely to worsen very quickly as wood fuel consumption increases and pressure to convert forests to agricultural land intensifies.

Neither wood demand nor annual forest replenishment rates is currently known with any degree of certainty. It is estimated that 80-90% of the Kenyan population relies primarily on firewood or charcoal and that such consumption is likely to amount to 1-2.4 cubic meters of wood per person per year. Most forestry experts believe that total wood consumption (inculding wood for fuelwood, poles, buildings, etc.) exceeds forest replenishment rates both nationally and in the major areas of population concentration.

The projected doubling of Kenya's population by the year 2000 and projected confirmed migration to urban areas -- which implies a switch from firewood to charcoal, which has a lower net energy efficiency -- suggests that by the year 2000, Kenya's projected requirements are likely to be 2-2.5 times present levels. Present forest resources could not sustain such a consumption level. At the same time, the doubling of Kenya's population, in a country already suffering periodic deficits in food production, will substantially increase pressures to convert present forest lands to agricultural production.

Increased deforestation is bound to result. With it will come dam siltation, loss of wildlife habitat, and other negative environmental and economic consequences. Also, deforestation will bring continued increase in the price of charcoal and in distances required to collect firewood as well as accelerated monetiziation of wood, currently collected as a "free" good.

Options for righting the imbalance in wood fuel supply and demand include greatly expanded afforestation, increased productivity from government forest reserves and underutilized lands, integration of trees into crop and lifestock-raising systems, more efficient wood/charcoal conversion and end use, replacement of charcoal by wood in urban areas, and where possible substitution of other renewable energy sources for wood or charcoal.

(3) Impacts on the Poor:

Both of the above energy problems lead to particularly serious problems for the rural and urban poor. Increased wood/charcoal costs or collection times will be borne primarily by the poor. Reduced economic growth and reduced availability of government services will affect the poor. Finally,

problems of soil erosion and river siltation will affect the poor by hastening deterioration of their lands, by making potable water more difficult to obtain, and by worsening problems of production of basic foodstuffs.

It is particularly important to recognize the intimate link between deforestation, soil productivity, and the production of basic foodstuffs essential to the survival of the poorest segments of the population. Kenya's problems of food and fuel (especially woodfuel) are inextricably linked.

The particular characteristics and energy-related needs of the urban and rural poor -- AID's target population groups -- are discussed in more detail below.

B. Characteristics and Energy Needs of AID Target Groups*

About 45% of Kenya's rural population and 36% of its urban population live below a poverty line set at annual per capita food consumption values of less than about $45 in rural areas and less than $70 in urban areas. There is considerable geographic variation in poverty levels. In Nyanza and Western Provinces, for example, an estimated 56% of the population lives below the poverty line, while in Central Province only about 10% fall below that level.

In rural areas, where approximately 85% of the population lives and works, small-scale farmers holding less than 20 hectares make up the largest share of the population (about 70%). Only 3% of such smallholdings are larger than eight hectares. Pastoralists account for about 10% of the population.

The small-scale farm group is characterized by wide differences in standard of living which are related in part to variations in rainfall and altitude. The largest proportion of smallholders with incomes above about$260, for example, live in higher altitude tea, pyrethrum and coffee growing areas. Income levels are considerably lower in lower altitude zones where the more profitable cash crops listed above cannot be grown. The population is mostly concentrated in areas classified as having medium and high agricultural potential, though population pressure is now leading to some agricultural expansion into more marginal, lower potential areas.

Smallholders can be disaggregated into three groups according to relative welfare criteria:

1) The lowest 40% have annual incomes valued at less than $260 and are largely subsistence producers with little capacity for investing time or money in risky innovations. Individuals in this group may live either in marginal agricultural areas, on very small farms in high-density high -potential areas, or as tenants or squatters on farms owned by others.

* This section is summarized from the full version included in Annex B.

Most of them cook inside small huts using traditional three-stone fires. This segment of the population has least access to government services such as agricultural extension, schools, and dispensaries. They fetch water by hand, often from distances greater than one mile. They use very simple agricultrual tools -- often only a panga (machete).

The highest priority energy needs of this group include improved access to clean water for home consumption, more efficient ways of cooking with fuelwood and easier access to fuelwood supplies. Projects aiming to benefit this portion of the population must entail minimal risk to subsistence needs and must be very low cost (requiring a cash outlay of perhaps no more than about 5 or 10 shillings ($.70-$1.40) per household.

2) Those in the next 40% of the population have annual incomes valued at between $260-$830. Individuals in this group have a slightly greater capacity than those in the bottom 40% to invest some time or money in agricultural and other innovations. Some of them (perhaps 15-40%) can afford to cook with a jiko, rather than three-stone fire and perhaps a slightly smaller percentage use water tanks to catch rainwater from iron-sheet roofs for domestic consumption. Only a very small number, however, have access to dependable year-round water supplies within a quarter to half mile of their homes. They have more contact than the bottom 40% with agricultural extension agents and other government services. Women in this group are more likely than those in the lowest 40%, to belong to various types of women's groups promoting home and farm improvements. Secondary education for their children tends to be the first cash expenditure priority of this segment of the population.

The highest priority energy needs of these people include those of the first group but might also include charcoal-conserving jikos (if initial jiko purchase price is no higher than about $4-$7), or possibly improved cooperative level systems for processing (e.g., drying) cash crops. Since cash and labor are still very scarce resources in this group, projects would have to involve immediate and striking benefits in order to motivate people to donate more than a few shillings (perhaps 15-40) or hours (no more than 5 hours per week).

3) The wealthiest 20% of the smallholder population have mean annual incomes valued at $830 and above. About 50% of this group have farm holdings of more than four hectares. They tend to depend on jikos and kerosene burners for cooking while the very wealthiest use gas cookers. This portion of the population receives the bulk of extension services and its wealthier members represent the core of local-level school committees, Harambee project committees, and church committees. Most of them use water tank catchment systems at their homes and a very few live near community piped water storage supply systems. They are the group most likely to own improved livestock breeds and to adopt other innovations. Their first expenditure priority, like that of the first two groups, is education for their children.

Their priority energy needs would be better water supply systems and perhaps cheaper cooking and nonelectric lighting methods. This is the only group that might, in addition, be able to afford more expensive and

complicated projects such as biogas systems (only perhaps the wealthiest 5-10%), rural electrification (still far in the future in most areas), crop drying, water power for small-scale rural industry or commerical uses, or animal traction in agriculture.

A final group to be considered -- the urban poor -- tends to have cash incomes higher than the first two groups listed above, but most of this group's income is absorbed by high urban housing and food costs. The urban poor tend to depend on jikos for cooking and often on costly city water supplies (near their homes or at small-scale and often informal sale outlets).

The priority energy needs of the urban poor include cheaper and more efficient charcoal and possibly wood cooking techniques; lighting, and cheap, reliable water supplies. Better public transport is also an important need of the group.

C. Proposed Project Goal, Purpose, Strategy and Constraints

The project's goal is to reduce the adverse impact of fossil fuel imports on Kenya's balance of payments and to make progress in achieving a balance in wood fuel supply and demand. The project is intended to respond both to Kenyan national energy-related problems and to the specific energy needs of AID's target groups, the rural and urban poor. This will be accomplished through energy conservation, expanded afforestation and the increased use of renewable energy technologies.

The specific purpose of the project is to establish a capability in the Ministry of Energy to formulate policy and to plan, oversee implementation of provide technical assistance on, monitor and evaluate renewable energy programs and energy conservation measures in all sectors of the economy.

Program Strategy

The general strategy may be described as:

- Helping the Ministry of Energy establish the necessary energy, information and analytical base and then devise appropriate national energy policies and programs, with emphasis on measures to improve efficiency of use of petroleum fuels and measures to achieve wood supply-demand balance.

- Developing -- together with other donors -- sufficient renewable energy and energy conservation technical, analytical and extension expertise in the Ministry of Energy to enable it to support other GOK Ministries and nongovernmental organizations where they have related programs.

- Establishing, wherever possible as an addition to existing GOK nurseries, a network of centers in various ecological zones to serve as regional sources of seeds and seedlings, species research centers, and bases for demonstrating and disseminating afforestation, forest management, and agroforestry techniques appropriate to each ecological zone.

- Establishing an Energy Development Fund within the Ministry of Energy to support either promising demonstration/extension programs of nongovernmental groups or specific demonstration projects which promote afforestation, more efficient wood/charcoal cookstoves, more efficient charcoal kilns, use of wind or water power for community water supply systems, or other appropriate renewable energy technologies focused primarily on the rural and urban poor.

- Evaluation of technologies and extension approaches supported, in order to provide a basis for expanded afforestation, agroforestry, cookstove dissemination, charcoal production and other programs in future years.

Constraints

The USAID Renewable Energy Project has been designed to accomodate certain important constraints;

- The Ministry of Energy is new. It is likely to remain understaffed In particular, it has no extension staff of it own and must rely on the other ministries with which it still is in the process of establishing relationships.

- A number of donors or other organizations have launched or are planning energy-related projects. There is the danger that, without coordination, donor efforts could be duplicative or even conflicting;

- Other Ministries have ongoing operations which relate directly to the proposed programs. These Ministries include Environment and Natural Resources, (Forest Department nurseries, gazetted forests, and Rural Afforestation Extension Officers), Agriculture (nurseries, Agricultural Extension Officers, Home Economics Centers), Small-Scale Irrigation Program, and Farmers'Training Centers), Culture and Social Services (Community Development Officers and Assistants, Women's Bureau, Village Polytechnics), Livestock Development (field Water Engineers);

- In Kenya, as in most other countries, efforts to date to stimulate rural afforestation, use of more efficient wood or charcoal stove or adoption of renewable energy technologies have met with only limited success.

This project attempts to both economize and assist in the development of scarce Ministry of Energy personnel resources. It relies on existing resources of other Ministries where possible. It is intended to complement and relate closely to the programs of other organizations, notably the Beijer Institute fuelwood planning project. Finally, it is designed to stimulate experimentation with many different demonstration and extension approaches, using both governmental and non-governmental organizations.

D. Project Description

The project includes the following components:

(1) Initial Planning and Surveys

As AID's support of the Ministry of Energy/Beijer Institute Fuelwood Planning Project, the project provides through the State University of New York at StonyBrook, either a minicomputer or a terminal tied to the main Treasury computer plus software programming and training support to install a simplified version of the "AL-EDIS" system designed to meet the Ministry of Energy's needs and data availability constraints.

The project will provide short-term assistance to establish an Energy Data Bank and Library within the Ministry of Energy. Such assistance includes a U.S.-based librarian/research assistant to gather technical documents worldwide, an ample document acquisition budget, and short-term assistance in Kenya to establish the library and related accessions and retrieval system and to train the Ministry of Energy librarian in its use.

The Government of Kenya currently lacks the information systems, or staff expertise necessary to permit detailed assessment of energy use pattterns or identification and analysis of energy conservation opportunities and costs. Without such information, the AL-EDIS system will be of limited benefit. Therefore the following assistance will be provided.

- A long-term energy economist/planner with experience in energy assessment information systems and energy conservation analysis, to both assist in establishing the necessary energy information acquisition systems (with emphasis on industrial, transport and urban and rural household energy consumption information), and in using the resulting information to develop appropriate policies/programs to improve efficiency of energy use.

- Short-term consultants to assist in the establishment of energy information acquisition systems (using add-on modules to existing CBS surveys wherever possible) or to provide specialized energy conservation expertise in areas not covered by the long-term expert.

The long-term energy planning/conservation expert also will provide economic analysis support to all other aspects of this project, in particular the fuelwood/agroforestry centers and the Energy Development Fund, and will work with the Beijer project team. A specific assignment

will be analysis of wood/charcoal pricing, marketing, and distribution and identification and evaluation of options for (1) stimulating the production marketing, and distribution of wood for urban areas, (2) stimulating more efficient charcoal production, and (3) promoting integrated sustained-yield forest management and charcoal production systems.

(2) Institutional Development

(a) Technical Assistance and Training -- Forestry/Agroforestry

Afforestation is a pressing need within Kenya. Afforestation options include expansion of production from GOK gazetted forests, expanded fuelwood/charcoal plantations, community and individual woodlots, and integration of multipurpose trees into food production systems. Because of substantial existing World Bank support, the project will not address the problem of gazetted forests. For other types of afforestation, the project will provide the following institutional development support:

- A Senior Forest Extension Expert and a Senior Agroforestry Expert, with extensive African experience in respectively, nursery and woodlot development and integrated tree/crop farming. These experts will be assigned to the Ministry of Energy for the full three years of the project and will work closely with the Ministry of Natural Resources (Forest Department), Ministry of Agriculture (Soil Conservation, Agricultural Extension, and Farmers' Training Centers), the Beijer Institute Fuelwood Cycle Planning Project team, and non-governmental organizations. Their responsibilities include:

  - Initiating an informal survey of local nursery and tree-planting activities, largely through District-and Division-level interviews.

  - Supported by short-term consultants working under their direction, developing fuelwood and agroforestry extension curricula, and supporting information materials for incorporation at the Forest Training College, Forest Industrial Training Center, Farmers' Training Centers, Egerton College, Agricultural Institutes, and University of Nairobi, and for use in workshops for/with the Peace Corps, NCCK, and other groups. These consultants will also develop related public education and other extension materials, modeled after the Ministry of Agriculture Soil Conservation extension materials.

  - Directing the establishment and operation of AID-financed seed acquisition, seed production, species research, nursery, agroforestry demonstration, and afforestation extension efforts described in the "Applied Research and Demonstration" section.

- Working particularly with the Ministry of Agriculture's field extension officers to promote the use of trees to improve soil/crop productivity and to provide fodder, fuelwood, mulch, building materials, and other outputs for farm use or sale to outsiders. This approach to small-scale agroforestry has worked extremely well in some other African countries (notably Rwanda) and appears to have great potential in Kenya.

- Evaluating alternative fuelwood and agroforestry extension approaches.

- Short-term assistance to support the above experts in curriculum development, design of and participation in workshops for government or nongovernmental organizations, and development of informational materials.

- Printing of materials for the above courses or for public education purposes.

(b) Technical Assistance and Training -- Other Renewable Energy

The project will support two resident experts assigned to the Ministry of Energy -- one expert in wood/charcoal stoves, charcoal production, utilization of agricultural residues, and other biomass systems and one water supply and renewable energy engineer with African extension experience in wind and hydram technologies. These experts will provide technical assistance and training/curriculum development support to the Ministry of Energy and to selected other government and nongovernment organizations involved in extension or technology adaption. Examples of such assistance include:

(1) Cookstoves: (mud, clay, and metal cookstoves and wood and pottery jikos)

- Conduct an informal survey of cookstove use and cooking methods and of jiko and pottery makers' capabilities and design views with respect to stove improvement.

- Provide technical assistance, curriculum materials, and informational support to selected government organizations and nongovernment organizations (NGO's), demonstration, extension and evaluation program and/or to provide training or disseminate information on cookstove construction. The expert would work in depth with a few government organizations and NGO's selected by MOE and provide workshops and other general information support for other groups. Potential groups include:

  - Ministry of Agriculture-Home Economics
  - Ministry of Social Services-Women"s Bureau or Community Development Office
  - National Christian Council of Kenya
  - Egerton College

- Agricultural Institutes (Bukura, Embu)
- Farmer Training Centers
- Village Polytechnics
- Women's groups (e.g. Maendaleo Ya Wanawake)
- Adult literacy training organizations
- Church groups (YWCA, Salvation Army, etc.)

- Provide technical support to selected groups who can work with small entrepreneurs who might want to commercialize any of the new stoves that are developed. Examples of possible groups include:

  - Kenya Industrial Estates
  - Partnership for Productivity
  - National Christian Council of Kenya
  - Village Polytechnics

- Participate in formal courses and nonformal workshops of promising above groups, provide technical information and advice, and serve as a clearinghouse for information on activities of all such groups. He/she will oversee and assist cookstove and jiko demonstration projects financed through the Energy Development Fund.

(2) Charcoal Production:

- Conduct an informal survey of charcoal production methods, integrated into extension travels to Districts, Division and, when appropriate, administrative sublocations.

- Assist the Beijer project team in analysis of traditional vs. larger-scale national charcoal production policy and strategies.

- Provide curriculum development, technical assistance, and materials to Agricultural Extension Officers, Village Polytechnics, Forest Training College, Forest Industrial Training Center, Farmers' Training Centers, Egerton College and Agricultural Institutes, and others on improved charcoal production methods.

- Develop and distribute simple educational/promotional brochures aimed at traditional charcoal producers, for use by Forestry Department and Ministry of Agriculture extension agents.

- Oversee and assist demonstrations of improved charcoal production methods financed through the Energy Development Fund.

(3) Community Water Supply and Irrigation

- Conduct an informal survey of operations and maintenance experience with renewable energy technologies (windmills, hydrams, water wheel,

solar pumps) in water supply and irrigation systems in Kenya, integrated into District and Division-level extension travels.

- Work with the Ministry of Water Development in Nairobi and at the District-level and, later, with the Ministry of Agriculture Small-Scale Irrigation Program and with donors sponsoring water supply, land settlement, or irrigation projects (i.e., the AID Integrated Water Development Project, and Secondary Towns Project, CARE, and UNICEF), to identify and promote potential uses of renewable energy at specific water project sites.

- Prepare curriculum materials for and possibly participate in the training of District Water Engineers and technicians, or members of Harambee self-help water projects, emphasizing (1) considerations in the choice of motive power for water projects and (2) maintenance and repair of alternative renewable energy water systems.

In addition to the above activities, the long-term experts -- supported by short-term consultants as necessary -- will help promising national or local organizations prepare Energy Development Fund (EDF) loan or grant proposals, conduct technical and financial evaluations of EDF loan or grant proposals and submit recommendations to the MOE and to the appropriate District Development Committee; monitor projects supported by the EDF; provide technical assistance to EDF or other projects; and evaluate results learned from EDF projects.

Finally, before departing, the long-term experts will provide written evaluations of the efficency of the extension and training approaches supported, including an evaluation of each organization so supported.

AID will provide short-term consultants to assist the two long-term renewable energy experts in curriculum development, training or other extension-related areas.

(c) U.S. or Kenyan Training of Ministry of Energy Personnel

The staff of the Ministry of Energy is scheduled to increase from less than 100 persons at present to an approved level of 146 by the end of the current budget year, and further small increases are likely in future years. At the same time, recruiting difficulties make it likely that staffing will grow more slowly than these numbers suggest. Because it will remain difficult for the Ministry to spare any of its professional employees for long periods of time, the staff training budget will be allocated to short-term training such as that provided at StonyBrook or Gainesville, or to courses at the University of Nairobi, or other Kenyan educational institutions. The proposed budget would provide such training for 15 MOE staff members.

(4) Applied Research and Demonstration

The project includes two components:

(a). Fuelwood/Agroforestry Centers: The project will support the establishment of six agroforestry research, demonstration, and extension centers situated in various ecological zones. Each such center will include seed acquisition and species research appropriate to that region; distribution of seeds to other nurseries or, where direct sowing is feasible, to farmers or tree-planting organizations and government extension agents; distribution of seedlings of selected species and varieties for both extension and experimentation purposes; both conventional and agroforestry demonstration plots; and an extension/outreach staff to provide assistance -- directly and through government and nongovernmental extension groups -- in direct sowing techniques, nursery establishment and operations, post-planting maintenance, [illegible] with [illegible] livestock production.

The extension staff will work particularly with local Agricultural Extension Officers, Farmers' Training Centers, and non-governmental organizations (local church, women's, farmers', and other groups) to encourage introduction of trees on farms. They will monitor both progress in gaining acceptance for such introduction and results on farms where trees are introduced.

Each center will have a capacity to distribute roughly 200,000 plants by the third project year, in addition to substantial quantities of seeds; five conventional and ten agroforestry demonstration plots; one conventional and one agroforestry extension agent (Kenyan); and staff and equipment to support the nursery and associated extension and d monstration operations. Of the six centers, one each will be located in a semi-arid area (Kitui District), poorly drained highlands plains (Machakos District), the Western lake region (Kisii or Kisumu areas), a Western intermediate elevation (Kakamega or Vihiga areas), typical highland such as Limuru or Eldoret, and one of the two major ecological areas of the Coast.

Each center will be established at an existing GOK nursery or one just being started up. The GOK organization operating the nursery also will operate the center, under contract to MOE. In general, GOK nurseries in the highlands and other high productivity areas are operated by the Forest Department of the Ministry of Natural Resources and Environment, while those in marginal areas are operated by the Soil Conservation Division of the Ministry of Agriculture.

(b)Energy Development Fund: The project will provide consultant assistance and initial funding necessary to establish, within the Ministry of Energy, an Energy Development Fund. The Fund will provide grants or soft loans to organizations, on a cost-sharing basis, to develop and demonstrate innovative renewable energy technologies and extension approaches. The main purpose of

the Fund (or, as other capital is added, of the AID share of the Fund) will be to finance demonstration or dissemination of those priority technologies meeting basic needs of AID's target population groups. Recommended Energy Development Fund demonstration priorities are, in order of priority:

- Rural afforestation and agroforestry;
- Improved wood or charcoal stoves and cooking methods;
- Improved charocal production technologies and charcoal production systems which promote sustained-yield forest management;
- Community water suppy applications (particularly hydrams and windmills and possibly hand, pedal, animal powered pumps);
- Other renewable energy and energy conservation technologies which meet the needs of rural smallholders;
- Other renewable energy technologies which potentially could substitute for significant quantities of petroleum-or wood-based fuels but which require further demonstration before they will be adopted commercially.

The Fund will have two components of roughly equal size; (1) A component to provide program loans or grants of up to $75,000 each to support government or nongovernmental organizations carrying out promising extension efforts in the areas of afforestation, agroforestry, improved wood/charcoal stoves, improved charcoal kilns, or use of renewable energy for community water supply projects and (2) a component to provide project grants of up to $15,000 each to support specific demonstration projects of either GOK or non-governmental organizations, with 75% of the capital in this component to be allocated to the first five priority areas above.

Applications for the first Fund component will be received, reviewed, and approved by the Ministry of Energy. Loan or grant application procedures under the second component will be publicized/solicited at periodic intervals. Applications will be submitted to the respective District Development Committee for review. The DDC's will submit their recommendations to the Ministry of Energy, which will make final grant selection decisions. The Ministry of Energy will administer and monitor all grants awarded under either component.

The long-term experts provided under this project will assist in preparation of promising project applications, perform technical and economic reviews of grant proposals recieved by the Ministry, and provide technical assistance and training to support the DDC's in their reviews.

(5) Monitoring and Evaluation

AID will undertake the following monitoring and evaluation of this project:

- Forestry/fuelwood: Evaluation of results of tree species research, nursery operations (including costs, survival rates, distribution problems), effectiveness of alternative extension approaches (both those through the AID-financed nursery complexes and other supported indirectly), responses to afforestation extension efforts, and

response to and results of agroforestry demonstration and extension efforts.

- Evaluation of costs, technical performance, and suitability for large-scale adoption of wood/charcoal and other renewable energy systems supported under the Renewable Energy Project.

- Evaluation of alternative training, technical assistance, and extension approaches and of urban and rural responses to both those approaches and the technologies being disseminated.

AID will provide a small-team early in the project to prepare a detailed monotoring and evaluation plan. Annual project monitoring reports will be submitted by the technical assistance contractor to MOE and AID. Finally, mid-term and final project evaluations will be conducted by a team acceptable to MOE and AID.

F. Relationship of Project to GOK Development Plan, CDSS, and Other USAID-GOK Projects

GOK Development Plan

The project is compatible with and supportive of the GOK Development Plan on a number of different levels.

The 1979-83 Development Plan outlines the following objectives for the energy sector:

1) increasing the supply of energy to meet the requirements of the economy;
2) rationalizing the use of imported petroleum;
3) developing indigenous energy resources; and
4) lessening dependence on imported fuels.

The Renewable Energy Development Project contributes to the achievement of these objectives by providing assistance to the Ministry of Energy to develop energy policies, to establish an effective program of energy conservation, to substitute renewable energy in place of petroleum where appropriate, to expand its afforestation program and to promote more efficient wood-charcoal conversion and end-use.

The Project also supports a number of other policies and objectives of the Kenyan Development Plan not specifically related to energy. These include Kenya's primary goal of poverty alleviation and others such as preserving its natural resources, conserving its soil, providing water to all Kenyans, utilizing appropriate technology, strengthening Kenyan institutions, promoting small businesses, and focusing attention on the Arid and Semi-Arid Lands.

The Project will contribute to the alleviation of poverty most directly by providing easier access to fuelwood, water and more efficient cooking devices. The project will support and complement the tree planting, nursery development, species research and manpower training programs of the Ministry of Natural Resources, Forestry Department and the Ministry of Agriculture Soil and Water Conservation Services Board. The project also intends to provide support to a number of other Kenyan institutions, governmental and non-governmental, to enable them to play a role in research, development, demonstration, and extension of appropriate renewable energy technologies. Another important aspect of the project will be to encourage informal sector business to produce these devices, another priority of the Kenyan Development Plan.

CDSS

The Kenya CDSS for FY82 identified energy requirements as one of the key development problems facing Kenya. The strategy proposed is "to enhance the Ministry of Energy's institutional capability and to demonstrate application of several renewable energy technologies suitable to socio-economic, cultural, and climatic conditions of Kenya". In addition, the CDSS called for the increased wood fuel production through pilot demonstration activities. It also identified target population groups which have been used to develop priorities for this Project.

Other AID-GOK Projects

Other USAID-GOK projects related to the Renewable Energy Development Project include the Secondary Towns Shelter and Community Facilities Project (HG-006), the Arid and Semi-Arid Lands Project (ASAL) (615-0172), Feed Crop Storage (615-0190), Community Water, and small-scale enterprise development projects being carried out by Private Voluntary Organizations.

The Secondary Towns project, directed to eleven towns ranging in size from 5,000-15,000, will finance sites and Services development, core housing

and upgrading of existing housing. The project will also involve the provision of community services, including water and employment generation activities. Energy saving approaches to construction, cooking facilities, and provision of water are potential project elements.

The community water project involves design and construction of water supply systems in which the Ministry of Water Development would provide a main water line and the community would be responsible for construction, operation, and maintenance of the distribution system to community water points. The project also will include technical assistance, training and funding for community rehabilitation of existing non-functioning systems.

The ASAL project covers soil and water conservation, improved agricultural practices, water resource development, crop and livestock production and afforestation in the Kitui District of Eastern Province. A related project with direct relevance to the Renewable Energy Project is the formulation of detailed plan for the development of eight tree nurseries in Kitui District. One of these nurseries could potentially be upgraded as part of the Renewable Energy Development Project.

The Crop Storage project includes institutional development, training, and demonstration relating to grain drying and storage practices. The solar drying component of the Project potentially could relate to the Crop Storage project.

The small-scale enterprise activities operated by Technoserve, Partnership for Productiviey, National Christian Council of Kenya and others, could potentially become involved in the commercialization of improved cooking devices.

G. Relationship to Other Donor's Projects

A number of other donors have initiated or are contemplating projects in energy or related areas. Those projects about which there is information are summarized below:

(1) Bilateral

- Federal Republic of Germany: Is in the final stages of negotiating a 2-3 year, DM 16.5 million energy project to include participation in the MOE/Beijer Fuelwood Cycle Planning Project; demonstration projects in stoves, and integrated wind and solar electric systems; assistance in establishing an Energy Research Center at the University of Nairobi; and funding to Kenya Industrial Estates and other financing institutions to provide energy project loans. Also, separately supporting the Mzinga Dam project.

- Japan: An ongoing three-year project (K£133,000 this year) to assist the Olkaria goethermal power development program.

- United Kingdom: Intends to provide three petroleum development advisors plus associated training; has proposed afforestation and rural electrification projects in Embu, Meru, and Isiolo, and is supporting the Mzinga Dam project.

- Sweden: Allocates the interest differential (K£222,999/year) on a former power development loan for rural electrification projects.

- NORAD: Assisting in review of petroleum information and conducting further studies of the Turkwell Gorge hydropower project. May help finance Turkwell Gorge.

- Canada: Provides grants for rural electrification, is negotiating to provide rural electrification engineering assistance, and currently is installing three major power transmission lines.

- Finland: Initiating a FM 1.6 million feasibility study of mini and micro hydropower in Western and Nyanya Provinces.

- Netherlands: Participating in the Beijer Fuelwood Cycle Planning Project.

- Italy: Has expressed "very preliminary" interest in establishment of an Energy Research and Development Institute.

- Brazil: Currently providing short-term power alcohol consultant assistance, may negotiate a longer-term technical assistance agreement.

- Iraq: Allocating a portion of a large country program credit to geological surveys and training of geophysicists and other petroleum specialists.

- Abu Dhabi: Has expressed preliminary interest in financing provision of electric power for the Bura Irrigation Scheme.

(2) Multilateral

- World Bank: Currently providing loans for the first and second Olkaria geothermal projects, supporting a feasibility study of the Kiambere hydropower project, and seriously considering a possible project to review existing petroleum data and legislation.

- UNDP, UNIDO: Committed to providing a long-term energy policy advisor with a petroleum background and short-term experts to advise on petroleum marketing/distribution and a possible airborne geophysical survey program; MOE is awaiting final report of power alcohol consultant team; UNDP considering a UNIDO biogas proposal; may provide a short-term advisor on renewable energy in rural areas (Photovoltaics minihydro, and windpower for rural electrification); and may provide further geothermal exploration assistance.

- EEC Currently reviewing consultants' proposal to assist in preparation of a national energy strategy, evaluate MOE organization, and advise on the establishment of an Energy Research and Development Institute. Also supporting the Mzinga Dam and may support Turkwell Gorge.

Because of the concern over potential for duplication, the MOE held a meeting of all donors in August 1980 to discuss their respective projects. Based upon this meeting and discussion with individual donors, AID is convinced that this project does not duplicate other donors' current or contemplated projects.

The MOE intends to convene such donor meetings on a regular basis to assure close coordination among all donor energy projects.

H. Conditions Precedent to Disbursement and Special Covenants

Conditions Precedent

(1) First Disbursement. Prior to the first disbursement under the Grant, or to the issuance by A.I.D. of documentation pursuant to which disbursement will be made, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D., in form and substance satisfactory to A.I.D., a statement of the name of the person holding or acting in the office of the Grantee specified in Section 8.1, and of any additional representatives designated pursuant to Section 8.2, together with a specimen signature of each person specified in such statement.

(2) Disbursement for Energy Development Fund. Prior to any disbursement under the Grant for purposes of financing the Energy Development Fund described in Annex H to this paper ., or to the issuance by A.I.D. of documentation pursuant to which disbursement will be made relative to such funds, the Grantee will, except as the Parties may otherwise agree in writing, furnish to A.I.D. in form and substance satisfactory to A.I.D., (a) proposed criteria, with details, for approval and implementation of activities under that fund and (b) proposed Ministry of Energy staffing and administrative arrangements with respect to the fund. Such submission to A.I.D. will be consistent with the guidelines contained in Annex H hereto, relative to the Fund.

(3) Disbursement for Grantee Contracts. Prior to any disbursements, or to the issuance by A.I.D. of any documentation pursuant to which disbursement

be made, relative to Grantee contracts for technical or other services, or for the procurement of equipment or commodities under this Agreement, and except as A.I.D. may otherwise agree in writing, A.I.D. will approve in writing such executed contracts.

(4) Disbursements Relative to Beijer Institute Study. Prior to any disbursements, or to the issuance by A.I.D. of documentation pursuant to which disbursements will be made, relative to use of Grant funds in support of the Beijer Institute Study described in Annex D hereto, the Grantee will, except as A.I.D. may otherwise agree in writing, furnish to A.I.D., in form and substance satisfactory to A.I.D., evidence that the additional funding necessary to complete that study either has been committed or will be committed on a timely basis.

(5) Disbursements Relative to Fuelwood/Agroforestry Component. Prior to any disbursements, or the issuance by A.I.D. of documentation pursuant to which disbursement will be made, relative to the Fuelwood/Agroforestry Demonstration/Extension Centers component of the Project described in Annex K hereto, the Grantee will, except as A.I.D. may otherwise agree in writing, furnish to A.I.D., in form and substance satisfactory to A.I.D., evidence that the relevant functional Ministry agrees with respect to each center: (a) to make available necessary land and facilities; (b) to make its rural extension officers available for reasonable periods to participate in extension and training related to the project; and (c) to otherwise cooperate with the Ministry of Energy toward achievement of project objectives.

(6) Notification. When A.I.D. has determined that conditions precedent specified in Points 1 through 5 have been met, it will promptly so notify the Grantee.

(7) Terminal Dates for Satisfaction of Conditions Precedent. (a) If all of the conditions specified in Point 1 have not been met within ninety (90) days from the date of this Agreement, or such later date as A.I.D. may agree to in writing, then A.I.D., at its option, may terminate this Agreement by written notice to Grantee. (b) If the conditions specified in Points 2 through 5 have not been met within eighteen months of the date of this Agreement, or by later date as A.I.D. may agree to in writing, then A.I.D. at its option may cancel the then undisbursed balance of the Grant, to the extent not irrevocably committed to third parties, and may terminate this Agreement on written notice to the Grantee.

Special Covenants

(1) Project Evaluation. The Parties agree to establish an evaluation program as part of the Project. Except as the Parties otherwise agree in writing, the program will include, during the implementation of the Project and at one or more points thereafter: (a) Evaluation of progress toward attainment of the objectives of the Project; (b) identification and evaluation of problem areas and constraints which may inhibit such attainment; (c) assessment of how such information may be used to help overcome any such problems; and (d) evaluation, to the degree feasible, of the overall development impact of the project. Details concerning this evaluation program are contained in Chapter VI and will from time to time be discussed between the Parties and embodied in Project Implementation Letters.

(2) Donor Coordination. In recognition of the importance of consistency and compatibility of all external donor-funded activities in Kenya's energy sector, the Grantee covenants (a) to keep A.I.D. generally appraised, by means of a quarterly letter, of such activities, both ongoing and contemplated; and (b) to convene an annual meeting of such donors for the purpose of a general review of progress to date and future actions planned.

(3) Counterpart Personnel. In view of the importance of institutional development to the objectives of this Project, the Grantee covenants that, except as A.I.D. may otherwise agree in writing, Kenyan officers will be assigned to work on a substantially full-time basis with all expatriate advisors, both those resident in Kenya and those on short-term consultancies, funded under this project.

(4) Participant Training. In further recognition of the importance of institutional development, the Grantee covenants to provide on a timely basis suitably qualified personnel, for training in the United States or, elsewhere, in general accordance with the Implementation Plan included in Chapter V of the paper. The Grantee also covenants that, except as the Parties shall otherwise agree in writing, such participants will upon completion of training be placed in suitable positions, relevant to the objectives of this Project, within the Government. The Grantee's normal bonding requirements will be made applicable to all Kenyans undertaking such training.

(5) Project Coordination. In view of the several Kenyan ministries and other organizations involved with one or more aspects of the energy sector in Kenya, as indicated in Annex D to this Paper , the Grantee covenants to continue its existing energy coordination body, under the chairmanship of the Ministry of Energy, and to include representatives on that body from, at a minimum, the Ministries of Natural Resources and Environment, Agriculture and Water Development. The basic terms of reference of this coordination body will include periodic review of progress under this Project and the examination of usefulness of the Project to the energy-related work of those Ministries and other bodies. The Grantee covenants further to use its best efforts to promote and ensure cooperation in furtherance of

objectives between the Ministry of Energy and the above-named functional Ministries.

(6) Beijer Fuelwood Cycle Project. With respect to this Project component, the Grantee covenants (a) to assign professional staff as necessary to assist in installation and use of the AL-EDIS energy assessment system; (b) to make available facilities at the Ministry of Energy to house the AL-EDIS equipment and staff; and (c) with respect to a computer terminal to be furnished under the Project, to provide to the Ministry of Energy access to the Grantee's main computer, and necessary staff support, on the Grantee's normal terms for such access.

III. SUMMARY OF ANALYSES

A. TECHNICAL ANALYSES SUMMARY

Based on research undertaken by the project team as well as discussions with numerous government officials at the local and national levels and other informed Kenyans concerning the priorities and needs of Kenya's poor and the Kenyan energy situation, it is recommended that the project place primary emphasis on four areas: afforestation/agroforestry, more efficient cooking technologies, more efficient charcoal production, and water pumping for community consumption. Other renewable energy technologies which address the basic needs of the poor or provide an alternative to conventional fuels will be supported to a lesser degree.

1. Afforestation/Agroforestry

Most sources estimate that Kenya's forests amount to roughly 2 million hectares (20,000 km^2), less than 4% of the country's total area but (because most of its forests are located at higher elevation) some 15-16% of Kenya's medium to high potential land.* This may understate the total forest cover, since trees--and, equally important in marginal areas, savannah woodlands--also are found outside traditional "forest" areas.

As discussed in Appendix A, estimates of annual woodfuel consumption range from 10 to 25 million tons, or 15-36 million cubic metres, of roundwood equivalent per year. To this amount must be added wood consumption for other purposes, such as industrial raw timber and pulpwood, bomas, poles, etc. With average yields of probably no more than 3-5m^3/hectare, Kenya would be unlikely to be able to produce more than 6-10 million cubic metres per year on a sustained yield basis. Current production clearly is not on a sustained yield basis, so that both the growing stock and production apparatus--or "factory" itself are gradually being depleted.

A survey of environmental conditions indicates that, particularly on lands undergoing rapid population expansion and land near major urban areas, wood removal far exceeds the sustainable productivity of the vegetation. The removal of vegetative cover due to increased wood consumption or to intensified land clearing for legal or illegal agricultural settlement-- followed in many cases by excessive cropping or grazing--has caused severe soil erosion, diminished water quality, premature river and dam siltation, and other impact. At lower elevations, rapid population growth and consequent land competition has forced settlement of marginal, ecologically fragile lands, causing severe soil erosion.

Whatever the current consumption level, the projected doubling of the population (from 15 million to over 30 million persons) by the year 2000 and continued migration from rural to urban areas suggest that, within twenty years, the requirement for woodfuel will be 2-2.5 times present levels, or 30-90 million m^3 annually. A doubled consumption requirement could not be met from Kenya's present forests.

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* Land recieving more than 850 mm annually, considered the minimum needed to support agriculture on a continuing basis.

Greatly expanded afforestation, improved management of forest resources, and widespread adoption of agroforestry techniques must be undertaken. However, these efforts must be viewed as complements, not alternatives, to measures to use wood more efficiently.

a. Options for Meeting Future Woodfuel Demand

Forest Reserves and Industrial Plantations

GOK gazetted forests cover approximately 1.7 million hectares and are made up predominantly of indigenous forests, with some exotic softwood and hardwood plantations. Most gazetted forest area is maintained as protection of water catchment areas rather than as a source of wood production. Only about 10-13% of the country's total fuelwood comes from government forest reserves.

There is substantial scope for increasing fuelwood production from the comparatively small (150,000ha) GOK forest plantation area. Present yields are 13-19 m^3/ha of saw timber or pulpwood. By contrast, an industrial plantation in Malawi with similar ecological conditions achieves yields of 40 m^3/ha, of which 30 m^3 is fuelwood.

The forest reserves occupied by natural forest vegetation, especially those on the highlands, pose a very different problem. Several of these forests are at present disintegrating at an alarming rate due to settlement of "squatters". It has become administratively and politically difficult to stop squatters from entering the forest reserves. At the same time, some of these forests constitute important water catchment areas and their destruction is endangering the water supply below, leading to the premature silting of dam sites, and contributing to rapid deterioration of productivity of agricultural land.

What option might work is unclear. The tradition African "Taungya" system of periodically rotating settlements within the forest reserves potentially could at least lessen the potential damage. Alternatively, separating existing farmland from the areas of natural forest that need protection may constitute an effective barrier to encroachment.

There are few large private forest plantations in Kenya. EATEC operates one of the largest plantations in Africa, to produce black wattle as a source of tanning extract (and, as an important by-product, charcoal), near Eldoret. Black wattle also is grown commercially elsewhere in the highlands. Eucalyptus trees also have been planted on a considerable scale, although a commercial wood marketing and distribution system using Eucalyptus has not been established. A few tea and tobacco plantations meet some of their fuelwood requirements from their own lands. In general, however, private farmers appear to see little incentive for growing wood.

Experience in other countries--and experience in Kenya with black wattle--suggests that private industrial forest plantations and large (and small) scale farmers will respond to price incentives to grow trees. Current

Forest Department stumpage prices appear to be too low to enable profitable private production. The scope for expanded private production and incentives necessary to elicit such production should be investigated. Also, contracting for private management of selected forest reserves should be considered.

Communal and Individual Forest Management

There is widespread interest and activity in rural afforestation. Efforts include the Forestry Department's Rural Afforestation Extension Service, the Ministry of Agriculture's soil conservation program, programs of non-governmental organizations such as the NCCK, the National Council of Women of Kenya, and Wild-life Clubs of Kenya, and local efforts of village chiefs, church groups, women's groups schools, etc. In many cases, such efforts have been successful, and the GOK's rural nursery and extension network provides a basis for future expansion. However, shortages of appropriate seeds and seedlings, lack of advice on when and how to get out seedlings and lack of proper post-planting maintenance have resulted in both too few trees being planted and very low survival rates for those that are planted.

Currently Underutilized Lands

One option for communal or individual afforestation is to use land-found even in the densely-settled parts of Kenya that could be more profitably employed for growing trees than for anything else and which is not at present included in the forest estate. Examples of this category include:

- Stony, rocky land where underground fissures nevertheless make deep root penetration possible;

- Slopes so steep that they would be seriously exposed to erosion if farmed or trampled by cattle;

- Sloping areas where the soil previously has been exhausted and the land invaded with Lantana thickets;

- Areas characterized by seasonal water logging, assuming that suitable species are selected and planting is carried out on raised mounds or ridges;

- Highlands areas covered by heavy clays that presently carry only low-yields pasture and isolated trees, if sub-soiling or other techniques are used; and

- Semi-arid areas which can support only silviculture, generally combination fuel-fodder plants.

Communal Lands

Most County Councils have designated land specifically for afforestation In addition, administrative sub-locations (particularly in marginal areas

where damage from soil erosion is already visible), churches, schools, and other groups appear to be setting aside land for afforestation projects.

A survey is required to ascertain how much land within this category has a potential for forestry development. In addition, difficult issues regarding communal rights and responsibilities must also be addressed (See Social Soundness Analysis).

Individual Farmers

Close to urban centers or in the case of trees with commercial potential, it is possible that fast-growing trees in some cases may constitute a more profitable crop than grains even on very good farmland. In general, however, if adequate incentives are provided, planting of trees or the maintenance of natural tree vegetation on pasture and farmland will, for both economic and social reasons, be acceptable only if the trees help to enhance food production in addition to their wood-yielding function. Multi-purpose trees which combine firewood, fodder and soil enrichment attributes potentially can increase crop yields to the farmer as well as contribute to general improvement in soil conservation and fertility. Particularly in semi-arid and arid lowlands, an improved agroforestry system can help protect the fragile and endangered ecosystem as well as producing valuable fuel, fodder, and other products.

Despite historical integration of indigenous trees into traditional farming patterns, most Kenyan farmers are no longer familiar with the idea of growing herbaceous food or fodder crops in association with trees. Moreover, very little research data is available within Kenya that would make it possible to provide farmers with detailed and precise advice about how to increase the productivity of their land by associating trees with their conventional crops. Relevant data on this subject may be obtained from Rwanda (where very interesting agroforestry and extension work is being carried out), the International Institute for Tropical Agriculture at Idadan, and elsewhere, including the Nairobi-based International Council for Research in Agroforestry (ICRAF). However, research, demonstration, and extension work must be conducted on a broad-scale if large-scale planting of farm trees is to be achieved.

b. Program Needs

Species Selection

The selection of tree species for reforestation/fuelwood development is an important technical input to the implementation and success of reforestation/fuelwood development programs in Kenya. Kenya is characterized by a wide range of soils, climates and micro-environmental conditions. Tree species which grow satisfactorily in one area of the country may not perform well elsewhere. However, most research in Kenya has been limited to highland species. A list of genera and species recommended for testing is shown in Annex A. The list includes both exotic species and indigenous trees. A large numger of potential fodder trees and leguminous trees with nitrogen fixing capacity as well as a few quality timber trees

are included.

Seed Production/Acquistion

Enough already is known about several suitable plantation species for highland conditions to be confident about seed use, e.g. Black Wattle (Acacia mearnsii) and several Eucalyptus. Similarly, for certain soil types in the coastal region, species such as Eucalyptus camadulensis can be relied on. Finally, research and development has been carried out by non-GOK organizations--the NCCK, Baobab Farms LTD., Kositei Catholic Mission, IPAL, and others--to identify and establish trees on different types of marginal land. In some cases, limited quantities of seeds of promising species are available for distribution.

Assistance to Afforestation Groups

The major needs of non-governmental organizations are appropriate seeds, assistance in developing public education materials, and training and technical assistance in nursery development and post-planting maintenance. In addition, limited financial assistance to support an afforestation program manager/coordinator and/or travel expenses would permit promising national or regional organizations to expand their assistance to local afforestation groups.

In addition to financial assistance, AID should provide:

- At least two forestry/agroforestry experts to provide technical assistance to government and non-governmental organizations, as well as to manage related aspects of the AID project;

- Development, or support of groups such as ICRAF in the development of, rural afforestation and agroforestry curricula for incorporation at the Forest Training School, University of Nairobi Faculty of Forestry, Agricultural Institutes, Farmer's Training Centers, Adult Literacy training centers, and other appropriate formal and non-formal educational centers capable of reaching extension officers, farmers, or both.

- Newsletters, information documents for educational institutions, posters, films, articles and other public education materials.

- Combined experimental and extension nurseries, to conduct the species research recommended above, provide seedlings to local organizations, demonstrate techniques of nursery establishment and maintenance, and provide a base for local extension efforts.

Agroforestry Demonstration and Extension

Because of the importance of agroforestry and the lack of current Kenyan organizations focus on integrated silvicultural/agricultural farming patterns, AID should support a series of demonstrations of the technical and extension/acceptance aspects of agroforestry in each of Kenya's major ecological zones, using the existing GOK nursery centers as a base. Such demonstrations should include species trials demonstration plots and outside demonstration planting, (to include both establishment of conventional forest plantations and planting of trees on land used for cropfarming, and pasture as part of multiple crop agroforestry systems) and a major extension component.

Information Gathering and Analysis

This project will provide financial support for the MOE/Beijer Institute eight-month, $1.4 million Fuelwood Cycle Planning Project. The Beijer project should provide most of the required fuelwood information and analysis. This project can assist, however by:

- Using its long-term experts to document and then continually monitor rural afforestation and agroforestry activities throughout Kenya;

- Providing and analyzing information on Kenyan forest resources and land use generated by the AID Remote Sensing Center; and

- Using its long-term experts or consultants to investigate opportunities to promote expanded wood production on known underutilized lands.

2. Cooking Technologies

In rural areas, which constitute 85% of Kenya's population, the predominant cooking technology is the three-stone fire. In urban and urbanizing areas and wood-short rural areas a metal brazier called a jiko is used by most people. In the last five years, more efficient cooking technologies--primarily enclosed wood stoves made of mud, clay or cement, and improved jikos have been promoted, but have received limited acceptance.

The following alternatives should be analyzed in the cookstove program: low-cost improvements to the three-stone fire, supplements to the three-stone fire, enclosed high-mass wood stoves, improved jikos and metal woodstoves for urban areas.

Improvements to traditional cooking fires include concentrating heat onto the cooking pot by surrounding the fire with used aluminum sheets or foil, providing good access to the bottom of the cooking pot, and constructing horse-shoe shaped baffles made of mud or bricks to act as a windshield.

splitting and drying the wood before use, using small (1"diameter) pieces, and arranging the wood to allow proper air intake and mixing also are important for an efficient fire.

Supplements to a three-stone fire such as insulated containers (haybox cookers), solar warmers, incorporation of smoke release passageways, and burying enclosed pots with burning embers also should be analyzed.

There is a wide variety of high-mass stove designs, including Kenyan designs (e.g., Karai and Kakamega stoves) as well as introduced designs (primarily variants of the Lorena stove). While it is difficult to generalize, improved stoves often contain the following features: a firebox or hearth for containing the fire, a flue for directing the flame and fumes of combustion, a chimney to provide a draft for drawing air and venting smoke, an air inlet to supply oxygen to sustain the flame, baffles to direct the convective heat current, heat exchangers to transfer heat to the pot, and dampers to control the flowing air or draft. Enclosed stoves can be made in a variety of designs using many different types of materials such as mud, dried bricks, sun-dried clay and mud bricks, clay-sand mixtures, dung, agricultrual residues and metal.

The most typical household jiko is cylindrical in shape, made of scrap metal about 1mm thick and consists of the metal shell, a fire grate with opening, and appendages-base supports, access ports for tightening and ash removal and cooking vessel supports. Jiko improvements include the use of heavier plate steel and the incorporation of double walls to reduce heat loss, chimneys and dampers, funnels placed on the grate to divert heat onto the pot, bellows, metal rings to prevent heat escape when smaller pots are used, and soil cement insulating lining.

3. Charcoal Production

The simplest way of making charcoal and the principal method used in Kenya is in earth kilns. In this method pieces of wood are placed under the soil surface and the top is covered with layers of grass and an insulating layer of damp soil. The main advantage is that no capital is required. The main disadvantages are that yields are extremely low (8-10% by weight) and dependent upon the skill and experience of the producers.

Stack kilns are also prevalent in Kenya. They are normally built on a level site with the front end slightly raised to help the fire creep to the end. The floor is marked in a triangular shape from 5-9m long and .5-3.5 meters wide Stout poles are laid covering the ground. Pieces of sticks are packed in between the layers of poles to help the fire creep through. The stack is covered with a layer of green grass and then damp soil. The procedure, which takes 5-10 days, is more efficient than earth

kilns but less widely used.

Portable metal kilns are available in Kenya costing about Ksh.23,500 (over $3,200). Other activities include one large industrial charcoal operation consisting of 28 large brick kilns, a continuous feed charcoal retort using coffee hulls, and research on pyrolysis.

The project proposes to place major emphasis on improved traditional charcoal production including no-cost, low-cost, and more substantial improvements which promise up to 50% greater recovery by weight. Support will also be provided for analyzing the costs and benefits of large scale charcoal operations.

No-cost improvements consist of drying the wood as much as possible, separating it into relatively uniform pieces, packing it tightly, and ensuring that the earth covering is at least 6-12 inches thick. Basic tool and material improvements requiring small investments include use of larger axes to facilitate more uniform cutting ($4-7), tempered curved pruning saws to harvest smaller limbs and branches ($4), and/or improved pruning 24-30" bow-saws for intermediate sized wood ($7). Finally, the insertion of sheet metal between the mounded wood and the insulating earth layer, using flattened debes or other scrap metal, is a low-cost (under $5) improvement which can improve the yields of traditional earth kilns by 20% or more.

More substantial alterations to traditional earth kilns have been developed in other countries. One example is the Casamance Kiln used in Senegal. Instead of building the stack directly on the ground, an air space is built underneath by means of a network of logs. A circumferential air chamber is also created by laying an apron of brush on the outside. A chimney is placed beside the stack. Besides significantly increasing efficiency, the Casamance Kiln can use various sizes, density and moisture contents of wood, and is faster than traditional kilns. Smaller logs will stop burning when carbonization is complete. The applicability of such methods in Kenya should be examined by the project wood/charcoal utilization specialist.

A number of important issues must be carefully considered before larger-scale charcoal production, such as portable metal kilns, are promoted. While they conserve wood, they also are more capital intensive, require greater technical skill to operate, and would reduce income and employment for perhaps thousands of traditional producers. It is recommended that the Ministry of Energy conduct an extensive policy analysis of the socio-economic issues involved before encouraging these and other large-scale charcoal kilns.

Multiple yield pyrolysis is considered too expensive and too subject to technical difficulties to warrant project support.

4. Water Pumped By Renewable Energy

Most water systems installed in rural Kenya to date are pumped supplies from boreholes, rivers or shallow wells. Most of these pumps are driven by diesel motors. Others are driven by electricity, wind, solar, water, and human power. Gravity feed systems have been installed in areas where the source of water is suitably higher than the population served. In addition, some rainfall catchments have been constructed generally on roofs of community buildings.

The costs of operating and maintaining diesel motor-pump combinations has been escalating rapidly in recent years, due primarily to fuel cost increases and increasing parts and labor costs. Another very serious problem with diesel-powered systems is pump or motor breakdown. A skilled mechanic is needed to ensure proper system operation, and such mechanics are in short supply. It is estimated that no more than half of installed diesel pumpsets in rural areas operate on a regular basis.

It is proposed that the following alternatives be analyzed for their applicability in Kenya: wind pumps, water-driven pumps, human and animal powered pumps, and solar stills.

Windpumps

A variety of windmill designs are available in Kenya. They all transform the energy of the wind into rotational motion and then into a reciprocating stroke. This reciprocating stroke actuates a pump in a tubular shaft.

A number of imported traditional "American Fanmill" type windmills have been installed primarily on large ranches, over the past fifty years. Standard models such as those provided by Aermotor, Dempster, Southern Cross, and others have operated reliably for decades.

More recently, there have been at least two sucessful attempts--and some unsuccessful attempts--to product windmills in Kenya. The Kijito windmill produced by Bob Harries Engineering Ltd. (Thika) and 12 PU 500 Windmill produced by Plows and Allied Products Ltd. (Kisumu) both are commercially available. Both windmills are too recent to permit conclusions regarding their long-term reliability, but both companies appear to have been quick to make modifications to work out initial problems with their designs. The Mbita Catholic Mission reportedly also is producing low-cost windmills in local workshops, but the project design team was unable to evaluate this operation. Earlier attempts to make Cretan or Arusha or other low-cost windmills in Kenya have not succeeded due to problems of operational reliability and requirements for skilled maintenance technicians.

The following projects concerning windpump utilization are suggested:

-A study of windpumping capability in Kenya should be undertaken. The data should be analyzed and made available to policy makers, development agencies, water development personnel, commercial equipment manufacturers and suppliers and other interested users to make them aware of the actual potential for windpump utilization in the country.

-Technical assistance and training on windpumps should be provided to the Ministries of Water Development, Health, and other interested government agencies, and non-governmental organizations. A review of proposed water schemes should be undertaken to determine where proposed new diesel pump installations may be feasibly replaced by small windpumping systems. The agency or group could then apply to the Energy Fund for financing of the systems.

-The project's renewable energy expert should assist in site and system selection. Assistance should also be provided for training and to set up a monitoring and evaluation process, to analyze the economic, financial, and social costs and benefits to the community and the Ministry of using windpumps instead of diesel pumps.

Hydraulic Rams

For applications where there is a river or stream with sufficient working fall and water flow to power a hydram to drive water uphill to nearby users, hydraulic rams offer probably the least expensive and most reliable water system.

Hydraulic rams use free energy. They require very little maintenance when compared with diesel pumps. In addition they can operate continuously essentially unattended. At the same time, many of the estimated hundreds of hydrams installed in Kenya are not operating because of failure to perform the minimal maintenance required (clearing inlets of debris, periodically releasing air pressure, and replacing a rubber clapper once every 2-3 years) or because a valuable brass valve has been stolen.

There are many more areas of the country that could make use of these systems, and their use should be encouraged and supported by the government. The project's water/renewable energy expert will conduct a survey of hydraulic ram installations in various regions. This survey will be used to provide baseline data for the Ministry of Water Development and other agencies involved in water development concerning the actual and potential populations served by existing hydraulic ram installations, the problems associated with these systems, and the potential for increased use. Upon completion of the survey, if interest warrants, several workshops will be offered at the District level on the proper operation, maintenance and repair of hydraulic ram systems. Financing for hydraulic rams could also be applied for through the Energy Development Fund.

Other Related Technologies

Solar distillation and other water supply technologies are discussed in Annex A.

It is recommended that solar pumps not be included in the project for several reasons. Thermodynamic systems, typified by the Rankine cycle "Sofretes" pump, are sophisticated and expensive. These pumping systems require a considerable amount of maintenance and upkeep to keep them working. The level of technical expertise required for such maintenance is high. Thus, these pumps have had major maintenance problems and system shutdown is common.

Photovolatic pumps are reliable, require little maintenance beyond routine inspections, fit in more with conventional maintenance and operation procedures, but currently are very costly. In addition, other groups already are investigating the use of photovoltaic devices for water pumping. It would be wise to await the outcomes of these projects and to acquire more information regarding future photocell costs before deciding to go ahead with further installations.

5. Other Technologies

Annex A addresses solar drying, human-and animal-powered devices, and other renewable energy technologies.

As discussed in Annex A, a number of renewable energy technologies have not been included in the project. The most important of these are:

- Biogas systems, because of high cost of such systems (including the animals to produce the needed manure) put them well outside the reach of AID's target population groups and because the Federal Republic of Germany is initiating a large-scale biogas development program.

- Power alcohol systems because all but very small systems are beyond the reach of AID's target groups, the very small systems are not of interest to the GOK, and the MOE already is receiving power alcohol assistance from other donors.

- Solar electric system, because of their current high cost, their general lack of relevance to AID's target groups, and because of other donors' interest in financing such projects.

B. SOCIAL SOUNDNESS ANALYSIS

Population Characteristics

About 70% of Kenya's population is made up of various Bantu-speaking groups which are concentrated in three areas: the central highlands east of the Rift Valley, the coastal belt, and the Lake Victoria basin. The remainder of Kenya's population falls into two linguistic groupings: Nilotic and Cushitic. Nilotes include Luo, concentrated in lower parts of Western Plateau, Kalenjin and Maasai, located in the West Central highlands and throughout the Rift Valley, and related peoples which make up about 25% of the population. Cushitic-speaking peoples such as the Somali, Rendille, and Galla make up about 3% of the population, and are found in the Northern and Eastern Arid and Semi-Arid areas. The remaining 1 to 2% of the population are of Asian, Arab and European origin.

The rural population is primarily agricultural. Though farming is increasingly practiced by some Kalenjin and Maasai, many of them remain pastoralists. The Cushitic-speaking Somali,Rendille, and Galla are largely pastoralists.

There are significant regional differences in levels of economic development and in availability of services such as schools, hospitals, and transportation. In general, road and social service networks are best developed in the high potential, densely settled regions of the country, particularly in the highlands on the western and southern sides of Mt. Kenya. The government is significantly increasing development efforts in medium and lower potential areas to help redress regional inequities.

Adherence to traditional culture and modes of social organization also displays marked regional variation in Kenya. As might be expected, areas of least change are the lower potential areas of unreliable rainfall where government services are not widespread. Though some communal forms of ownership and labor cooperation exist in such areas, they are fairly uncommon in high potential, densely settled agricultural areas where land has been individually owned for about twenty years. The unit of agricultural production characteristic of most Kenyans is therefore the individual family farm or household.

Representatives of the central administration such as chiefs and sub-chiefs now occupy the major authority roles at the village level in rural areas. Organizations playing a major role in local political, social and economic affairs include cooperative societies in cash crop growing areas, and various development committees, women's and church organizations. The capacity of ordinary villagers to influence the decisions and activities of these groups and organizations varies greatly and often in direct relation to the level of education and prosperity found in an area.

Priorities and Motivation

The principal energy needs of Kenya's poor are improved access to water and fuelwood supplies, more fuelefficient cooking techniques, and improvements in agriculture and public transport. Among the presently available range of "appropriate technology" energy options, a relative few at the lower end of the scale in terms of cost and complexity have any immediate applicability to the poor majority.

It is important to recognize the distinction between national energy needs and priorties, and actual short-term development priorities motivating rural people. Since project activities compete with other tasks for the rural poor's very scarce labor and cash resources, the actual priorities motivating allocation of these resources by the poor must be taken in account.

At present the two highest development priorities of most of the rural poor are expansion of educational facilities and improved access to water supplies. These are the areas in which locally initiated and organized development projects (Harambee or self-help projects) are most common. It is more difficult to motivate people to work on projects with longer term or less immediately recognized benefits such as forest conservation or substitution of water powered pumps for diesel pumps. While the need for forest conservation and substitution of renewable for non-renewable (e.g., petroleum) energy resources is recognized at the national level, it is a need which is difficult to translate into action at the local level.

Time Allocation

With most families dependent on their own labor for all production and maintenance activities, little time is available for activities not directly related to the basics of day to day survival. Because women perform the bulk of family agricultural as well as domestic activities in Kenya, most of them are simply unable to donate more than a few hours(possibly 2-5) per week to development projects.

Reaching the Poor: Institutions, Extension and Communications

This project will use a number of government and non-government organizations to promote and spread renewable energy applications in rural areas.

It is individuals (particularly men) in the better off 20-50% of the population who have most contact with existing extension organizations. Lack of transport and personnel limits extension contact with less well off segments of the population, who often live in remote and inaccessible areas and who also may have little interest in extension services.

Local representatives of the central administration such as chiefs and sub-chiefs with their immediate and effective channel of communication with local people through barazas or public meetings, can play a role in publicizing and disseminating information concerning new energy technologies or projects. Infact, acquiring the public support of local chiefs and sub-chiefs is often an essestial means of gaining acceptance for any new project.

District, divisional and locational development committees, headed by D.C's, D.O.'s and chiefs, respectively, can also play a role. These committees would be useful for publicity, coordination and demonstration purposes, since their membership includes representatives of all government ministries operating at the relevant administrative level, as well as local educational, religious, and political leaders.

One of the most widespread and effective forms of community-based development in Kenya is Harambee self-help projects. These locally initiated and organized development projects are found in virtually all parts of the country and include such activities as building schools, hospitals, dispensaries, roads, cattle dips, and irrigation and water supply systems.

Both the community tree planting and water development components of the project could effectively make use of Harambee groups. It must be emphasized, however, that local initiation and organization is the strength of Harambee development efforts and that too much external assistance can be the death blow to Harmabee efforts.

A variety of non-government organizations which could be used to initiate energy projects or to disseminate information exist in Kenya. Some of them are based in Nairobi and have relatively little representation in rural areas, however they do perform important coordination and publicity functions. Other non-government organizations, particularly church organizations have specific areas of geographic concentration where they have fairly strong rural representation. However, church organizations represent a significant area of local and national political competition and this sometimes makes practical cooperation among churches difficult to achieve, particularly for water projects. Church groups might, however, be used effectively to help foster innovation in mud and clay cookstove technology.

Spread Effects

To the extent that AID is able to set up replicable mechanisms for energy technology experimentation, demonstration, and diffusion, the project will have spread effects beyond the initial groups involved in these activities. Success will require direct participation by local people in developing both techniques and diffusion mechanisms. Spread effects will also be greater where the project requires little change in normal practices, such as tree planting on individual farms.

Since the demand for trees for individual farms in many rural areas exceeds the available supply of seedlings, achievement of spread effects among farmers will not be difficult if local tree nurseries are expanded and adequate seedling distribution mechanisms are established.

Community wood lots, on the other hand are more difficult to promote because they depend on creating new motivations and modes or organization in rural communities.

Achievement of spread effects will also require that the various technology options are evaluated and tested in the actual rural contexts where their dissemination is proposed. There is little diffusion of certain "appropriate village technologies" beyond domonstration centers in Kenya, at least in part due to social and economic disadvantages of the technologies being domonstrated.

The need for keeping complexity and costs of new energy technologies low in order to reach the rural poor is also essential to the achievement of spread effects. If these criteria are met, diffusion of new energy technologies in this project will then depend on making effective use of the full range of existing organizations and institutions discussed earlier.

Individuals in the second 40%, not the poorest 40% of the population will most likely have greatest access to and interest in existing extension, church and other organizations and institutions. If, however, successful and appropriate technologies are developed for diffusion by such groups, is is likely other individuals not directly involved would eventually learn of them by word of mouth and observation.

Social Soundness of Technology Options

Long term benefits of the project include: (1) a reduction in deterioration and erosion of agricultural land, which will help to alleviate further reductions in food and cash crop production potential; (2) a decrease in family labor required for gathering firewood and water which increases time available for more productive activities such as agriculture, and may improve family food supply and income; (3) a slowing of increases in family fuelwood and charcoal cash expenditures and other household essentials; (4) an increased supplemental income through more efficient charcoal production; and (5) an improved health and working capacity, resulting from a reduction in both the physically difficult burden or travelling long distances to fetch firewood and water and in the necessity to cope with fuelwood shortages by cutting back on the amount of food or number of meals cooked per day. Shorter-term benefits include: (1) generating individual employment opportunities for local people in extension, nursery, and tree planting activities; and(2) strengthened governmental and non-governmental institutions. Since about 85% of the wood consumed in tropical Africa is for domestic

household use, and since most rural households depend on wood for cooking, a project focused on wood fuel production and utilization can directly affect AID's poor majority target Group. Improved access to drinking water is also a high priority need which can directly affect this group.

Forestry

To help achieve a wood supply/demand balance, the project involves tree-planting at both the community and individual levels. Field visits have indicated that the demand for seedlings in rural areas is quite high and that there is an acute shortage of seedlings available for planting. Thus, seedling production and distribution is also an important focus of the project.

Community tree planting is limited by land availability and will depend upon effective cooperation with local County Councils, since it is they who control the remaining "communal" or public land in areas where land has been adjudicated and individually registered. Other problems with community woodlots include: 1) It will be necessary to recreate what is no longer an operating form of community organization and cooperation; 2) Determining how to distribute benefits (which is beyond the control of the project personnel) will be difficult; 3) Community lands tend to be of poorer quality; 4) Poorer residents may depend on communal lands for cultivation or grazing. Thus, the current use patterns of any potential community woodlots must be carefully understood before undertaking this activity.

It is possible that in medium potential areas where land is not yet adjudicated, and where communal forms of organization have not yet disappeared, community woodlots might be more successful. In both adjudicated and unadjudicated areas community woodlots may be more likely to be successful if multi-purpose trees are planted which yield other products such as fruit and fodder, as well as fuelwood.

Community fuelwood programs entail a number of organizational,administrative and motivation problems discussed above. In Kenya community fuelwood programs would probably be most likely to succeed if organized and initiated locally as Harambee projects, instead of being imposed from above by the government. AID could offer to provide seedlings to any such group wishing to begin a community tree planting project.

Agroforestry, another project component, can provide a variety of beneifts such as fodder for livestock, food for consumption or sale, building and fence poles improved soil fertility and soil conservation, all of which are likely to make tree growing attractive to many small-scale farmers Given existing patterns of small-scale farming in Kenya, tree planting along boundaries and scattered throughout various plots on a farm are likely to meet with more success than attempts to encourage

farmers to grow concentrated plantations or groves of trees. Farm sizes are simply too small to favor tree plantations since there are too many competing uses.

Tree species most likely to be quickly adopted by farmers are those with the most immediate and diverse range of benefits. Benefits must be clearly perceived by the farmer if he is to devote some of his scarce labor and time to such tasks as planting, weeding, pruning, and harvesting trees, as these tasks will compete with other essential agricultural tasks.

In many parts of Kenya, men and women are each responsible for certain specific crops and trees. Thus efforts to introduce tree planting on small farms must be done with an understanding of culturally defined sex roles and division of labor so that extension efforts can be directed to the appropriate family member, and also so it is clear at the start who will benefit from a particular program.

Finally, before establishing seedlings in a nursery, basic research should be done concerning existing tree species and uses in the area. Local people have extensive knowledge of local tree species and uses and this information should be used by project foresters.

Cooking Technologies

Four categories of fuel-conserving cooking technologies are considered: (1) improved three-stone fire; (2) improved wood stove: (3) improved charcoal stoves; and (4) biogas. As discussed earlier, improvements in traditional three-stone fires and wood stoves are most likely to benefit the poorest 40% of the population; improved charcoal stoves would not benefit the poorest 40%, but could benefit a large portion of the rest of the population (with the exception of the wealthiest 5-10% of the rural population).

Most of the rural poor in Kenya cook inside a small hut using traditional three-stone wood fires. Better off families who can afford the initial purchase and charcoal fuel costs tend to use a jiko, though some of these prefer the taste offood cooked over a wood fire. Kerosene stoves and gas cookers are preferred by the wealthiest 15-20% of the population and are considered important symbols of status and upward mobility.

Fuel-conserving improvements in cooking techniques would produce national level benefits by reducing wood consumption. Such improvements would also produce individual labor cash saving benefits for the rural poor.

Improvements in Traditional Three-Stone Fire Cooking

For cultural reasons, improvements in cooking technologies are likely to be a very low expenditure priority in most households, since cooking and collection of fuelwood tend to be regarded as unimportant, low status

tasks, and males tend to control cash. In any case, such innovations should probably require cash outlays of no more than about 5-10 shillings per family among the poorest 40% of the population. Wide diffusion of new technology among this segment of the population would also require very simple construction and maintenance procedures, since this group has very little access to existing extension services and institutions.

Current social benefits of traditional three-stone fire cooking which must be taken into account in designing improvements to it include provision of light, warmth for space heating, a social gathering point, wood preservative, and animal, insect and pest protection. Simple, low-risk, low-cost improvements in three-stone cooking which do not seriously alter wood fire benefits listed above might be feasible. For example, a horseshoe-shaped wall enclosing the fire might be acceptable if it were not more than a few inches high. Other means of improving fuelwood efficiency in traditional three-stone cooking, such as drying wood before burning, are often not possible because of severe labor and transport constraints the rural poor face.

Since many traditional foods require long hours of boiling, rather than simmering, it is possible that hot boxes or solar warmers would not be adopted. Additional research is needed to establish the suitability of these devices for cooking traditional Kenyan foods. In any case, they must be made from inexpensive locally available materials.

Mud and Clay Wood-Burning Stoves

Although various groups have attempted to introduce them, mud and clay stoves have as yet met with very limited success in Kenya. They are found primarily in demonstration units and in a few individual homes, often in conjunction with other cooking methods. It is not clear whether lack of information or disadvantages of the stove models themselves is the major cause of their limited diffusion. Careful assessment of user acceptability (durability, economic and social feasibility) should be undertaken of the various stove models being demonstrated.

Factors which may limit their acceptability include height, cost in labor and cash required to construct them, availability and durability of materials used and cultural factors, such as "backwardness", associated with a mud stove. In addition, available data suggest that some of the design criteria of improved stoves conflict with certain benefits (e.g., space heating, smoke) of traditional fires. On the other hand, as fuelwood becomes scarcer and purchase and collection costs increase, stoves with significantly lower fuel requirements may become a higher priority in rural areas and adoption rates may increase.

Improved Charcoal Stoves

Costs of purchasing the stove and fuel make charcoal stoves unaffordable for most of the poorest 50 to 60% of the population. At the same time, the sector which can afford jikos may not be willing to sacrifice scarce cash

at hand to pay the higher purchase price of an improved jiko in order to realize longer term benefits of reduced operating costs. In many cases, those who have more cash on hand would be more interested in buying a kerosene burner for status reasons rather than a better jiko.

Charcoal is, however, the preferred cooking technique for that segment of the rural and urban poor who depend on purchased cooking fuels since it is more convenient to use and easier to transport than wood. In comparison to mud and clay stoves, metal charcoal stoves have the advantages of durability, portability, small size, and low maintenance requirements. Scrap metal cooking technologies already exist in Kenya and because jiko makers are more centrally located (though mostly in the informal sector), it would be easier to disseminate new metal stove designs than it would be to disseminate improved mud or clay stoves.

As with mud and clay stoves, however, further experimentation with jikos is required to produce a design that is socially acceptable and economically viable. Some of the new jiko design in Kenya are said to be too slow, too heavy, too bulky, and too expensive for most people to be willing or able to pay the initial purchase prices. In addition, they take longer to build and are therefore less attractive to manufacturers.

Biogas

Biogas production techniques at the individual farm level will not be included in this project because costs of these systems far exceed the capacity of all but a small minority of the rural population.

C. CHARCOAL PRODUCTION

An estimated 70% of Kenya's charcoal is used in urban areas, about 45% in Nairobi. Most of it is produced in rural areas using traditional earth kilns in which an estimated 75% of the wood's energy is lost in the conversion process. For the rural poor, however, intermittent charcoal production is often an essential source of income. Thus, any yield increasing improvements in traditional charocal making techniques would benefit poor producers in both high and medium to low potential lands by increasing their cash incomes.

Demonstrating improvements in traditional charcoal production techniques to informal sector producers is extremely difficult, since many of these are "illegal" producers and many live in areas difficult to reach through existing extension mechanisms. Moreover, producers operating near the subsistence level have a low capacity for experimenting with new techniques. Simple improvements which lie within the range of some traditional producers include using dried wood, uniform sized pieces of wood, packing wood more tightly, covering the kilns with a sufficiently thick layer of earth, or adding insulation barriers (e.g., tin containers locally termed "debes") between soil layers.

Small-scale producers to whom information regarding improved techniques would be more easily disseminated are those who obtain permits from the Forestry Department to cut trees in specific forest areas. Some of these individuals can afford better tools such as axes, or occasionally cross-saws or chainsaws. Improved methods could be publicized to these producers, for example, via perhaps the Forestry Department or Ministry of Agriculture extension officials, though the former currently lack the necessary extension personnel.

Improved charcoal production techniques involving portable metal kilns or semi-portable brick and masonry kilns are much larger operations. Before investing heavily in large-scale, capital intensive charcoal production methods, it is necessary to evaluate more fully the degree to which this might significantly reduce income among small-scale traditional producers, who might be eliminated from production. Portable and semi-portable kilns require a considerable cash outlay for purchase. as well as high cost of transporting wood, which place such kilns beyond the means of traditional small-scale producers.

Finally, though rising rates of charcoal consumption involve short-term benefits for rural charcoal producers in the form of increased income, there are negative consequences in the long term, as rural wood supplies are depleted and the poor have to travel longer distances and spend more time and money on firewood to meet their own needs.

D. WATER TECHNOLOGIES

At least 4 million people in Kenya walk more than a mile in the dry season to get drinking water. According to a study of 10 districts in Kenya by Whiting and Krystall, women spend up to 6 3/4 hours per day fetching water. Since women tend to be responsible for a number of other domestic and agricultural tasks, reducing time required to collect water could significantly increase labor time available for more productive activities and could thereby indirectly produce increases in rural incomes and improve general welfare. Rural water supply systems can increase per capita water consumption levels and thus improve hygiene and produce health benefits for rural families.

Water supply projects are a very high priority in rural Kenya. An estimated 100 new Harambee water projects are begun each year. However, problems of scale, inadequate organization, and poor technical capabilities have limited the number of successful, locally based and initiated rural water supply projects. Rural water supply projects must be very simple, cheap or receive government assistance, and easy to maintain in order to be successful once external project personnel depart.

Windpumps

Windpumps are very site-specific, requiring adequate wind and water tables that are not too deep; however, when these conditions are met, a windpump could serve as many as two or three thousand people. One problem that must be dealt with is that windpumps require greater storage capacity then diesel systems since the amount of time they are pumping cannot be guaranteed.

As discussed in the technical analysis section, some of the windpump projects in Kenya have been unsuccessful due to problems with maintenance and repair and incompatible patterns of social organization. Notable successes in windpower appear to be confined to projects undertaken with external funding at religious missions or by individual (usually expatriate) large-scale farmers.

Since windmills have been in Kenya for several decades and have not yet generated striking interest by the government, very brief studies of the reasons for this are a necessary precedent to any large attempts to introduce still more windpump projects. A few demonstration projects might then be warranted if, for example, such studies indicate an unawareness on the part of policy makers of potential uses of windpower substitutes for fossil fuels. A publicity campaign would probably be required to counteract the prevailing attitude that diesel pumps are a sign of "development", while windmills are "backward".

In addition, the complexity and very high costs of purchasing and installing windmills mean that their establishment would require substantial government financial and technical support since they far exceed the financial and technical capabilities of many rural communities in Kenya.

Hydrams

Hydrams may be suitable for small-scale community water supply systems in areas such as the highlands, where much of the population is concentrated. A hydram can potentially supply about 120 families in an approximately three by four mile area. Because County Councils are turning from hydrams to diesel water pumps, second-hand hydrams are sometimes available for as little as about Ksh. 4,000, though new ones may cost Ksh.18,000 or more. Second-hand hydrams are thus within financial reach of groups of families in wealthier cash crop growing areas. Families living on dispersed farms along a ridge (a settlement pattern typical of much of the central highlands, Kikuyu, Embu, and Meru areas) have in some cases organized and contributed money to purchase and install a communal hydram, pipes and storage system to supply water for their own domestic use. Field visits to existing hydrams indicate, however, that even the fairly simple maintenance involved (usually simply cleaning intakes) is a problem, as is replacement of stolen and worn out spare parts such as rubber washers and gaskets.

Thus, these projects face several social, political, and technical constraints, and seem to require a fairly special set of circumstances in order to succeed. A return to use of hydrams in government, as opposed to local communal projects, on the other hand, requires a change in preference away from single unit diesel systems which produce greater output at increasingly higher fuel costs.

Human and Animal Powered Pumps

Although handpumps are not common in Kenya, they have certain intrinsic advantages which suggest they deserve attention. These include relative simplicity, low-cost, and ease of maintenance (at least in areas where the water level is high enough to use pumps with above ground access to the piston). A major disadvantage of handpumps, however, is their apparent lack of durability under conditions of heavy use by many individuals in community water supply systems. Handpumps might be considered in areas of high population density where a relatively small number of families could pool their resources to purchase one for their own shared use. Local social, and political organizational problems such as those discussed above with respect to hydrams could also be a factor in handpump systems.

Foot and animal powered pumps meeting low-cost, low-complexity and low-maintenance criteria should also be considered as an option though they are not widely known in Kenya.

C. SUMMARY OF ECONOMIC ANALYSIS

This project will help the GOK identify and introduce measures to increase commerical energy efficiency, stimulate afforestation and integration of trees into agricultural and livestock production, develop and disseminate more efficient cookstoves and charcoal production methods, and speed substitution of renewable energy for commercial energy in applications such as community water supply.

1. Energy Conservation

The two largest petroleum consuming sectors are transportation and industry, accounting for more than two-thirds of total consumption. There is significant potential for conserving energy in these sectors by incorporating a mixture of low cost "housekeeping" improvements as well as more significant changes. With an aggressive conservation program, over the next five years, Kenya could achieve zero growth in petroleum consumption or realistically even reduce petroleum imports. This will free capital for the investment which is essential if economic growth is to keep pace with population growth in Kenya.

2. Woodfuels

While it is difficult to quantify the costs of deforestation in Kenya, analyses by the World Bank and other organizations have documented the clear relationship between deforestation, increased soil erosion, and consequent dam siltation, decreased agricultural productivity, loss of wildlife habitat, and other economic costs. These studies conclude that costs of not addressing the deforestation problem far outweigh the costs of afforestation. Studies of the Tana River indicate that this same relationship applies in Kenya.

From the perspective of the individual farmer, current prices offer little incentive to grow woodfuel trees as a cash crop on high-productivity land rather than devoting this land to agriculture or livestock. There is some scope for increased production from marginal patches of land in high and medium productivity areas and from afforestation in marginal areas. However, the greatest potential -- and greatest economic incentive to the farmer -- lies in integration of multiple purpose trees into crop or livestock production systems. Devotion of 10% of a farm or ranch to appropriate trees can produce valuable fuelwood, poles, and fodder which at the same time improve soil fertility sufficiently to support agricultural yields equal to or greater than those achieved when none of the land is devoted to trees.

3. Cookstoves

Cookstoves may be either owner-built or purchased commercially. Owner-built stoves generally require a rural householder to "invest" time to build the stove in return for a flow of time savings due to reduced firewood collection requirements. Commercial stoves presently are limited almost entirely to charcoal jikos, where a cash investment in an improved jiko provides a stream of cost savings due to reduced charcoal purchases.

On purely economic grounds, both owner-built stoves requiring no cash outlay and improved jikos should yield very high economic returns -- over 1000% on a discounted basis. Since adoption of such improved cooking devices is spreading very slowly, economic analysis alone appears to be an insufficient basis on which to conclude that the program will be successful. The ability to overcome obstacles such as lack of time to make the earthen stoves, lack of information, required changes in cooking methods, lack of enough cash at any one time to purchase the more expensive improved jiko, or other factors discussed in the Social Soundness Analysis are more likely to determine whether or not improved cookstoves are adopted.

A third stove category is one in which rural persons using firewood must spend money -- either to buy a commercial woodstove or to purchase metal chimneys or other parts for an owner-built stove -- in return for a stream of time savings (reduced firewood collection time). Very little is known about the rates at which households at various income levels are willing to trade money for time or vice versa. Experience suggests, however, that for the rural poor -- AID's primary target groups and the group most likely to be using three-stone fires -- only very large and highly probable time savings would justify even a small cash outlay.

The Economic Analysis also addresses the costs of cookstove extension. Present unit extension costs to disseminate methods of owner-built stove construction exceed the price of most commercial wood/charcoal stoves.

4. Improved Traditional Charcoal Production

The economic return from inexpensive improvements to traditional charcoal making techniques -- such as improved wood harvesting tools or utilizing metal debes to reduce contamination of the charcoal -- exceed 100% after only one firing. On the other hand, small capital-intensive technologies such as "portable" metal kilns would seem to be beyond the reach of traditional small-scale charcoal producers; and, even where a producer has access to sufficient capital, the projected returns may not be sufficient to warrant the investment. These and larger-scale charcoal kilns, even if affordable by the small producer (which they are not), in fact appear to be economically attractive only to producers who own their own forests and thus must take into account the costs of forest maintenance or of deforestation. The great majority of charcoal producers in Kenya currently can pass this cost on to society and hence have little incentive to spend scarce capital to improve charcoal production yields.

GOK policies intended to gradually or suddenly move from the present system of small-scale intermittent charcoal production, where the producers do not own or take responsibility for the source of their raw materials, to some type of sustained-yield industrial production system potentially could have very serious negative economic consequences in poor rural areas. Aside from regular charcoal producers' loss of income and employment, one of the few sources of cost income for subsistence farmers would be removed. Also, this money stream may constitute a very real economic stimulus in some rural areas. The socioeconomic inputs of any such policy shift thus should be carefully weighed against the expected economic and ecological benefits of reduced or existing present deforestation trends.

5. Community Water Supply

As a public service whose capital investment generally is financed by governments, community water supply is characterized by a completely different economic decision-making calculus than are, say, cookstoves or other investments by individuals. First, systems entailing capital investments or operating well beyond the reach of AID's target groups even on a per capita basis may nevertheless be financed -- witness many diesel pumping systems. Second, government agencies may not be as responsive to perceived cost differences between systems as would an individual decision-maker. Finally, because of the separation between development and recurrent expenditures, a decision to invest in a given system does not necessarily entail a related decision to invest in the maintenance labor, spare parts, etc. necessary to keep that system operating once installed. All these characteristics can be seen in community water supply systems.

It is misleading to generalize, because the relative economics of alternative water supply or irrigation systems are highly site-specific. In general, however, where wind regimes and other conditions are appropriate, windmills are increasingly attractive compared to diesel pumpsets as the scale of

water-pumping needs declines. It is for small systems, where even a small diesel pump would be needed only one or two hours per day, that windpower appears economic. Were more known about frequency of outages for diesel units and the costs to users of those outages (due to increased water collection times, increased incidence of water-borne disease, etc.), windmills presumably would be economic over a broader range.

Hydrams are even more site-specific and appropriate to even smaller-scale systems. They represent a specialized application, meeting a specialized need, where diesel or other units cannot compete. Similarly, simple solar desalination systems meet a specialized need, and for that application they generally will be the most economical alternative.

Solar pumping systems are not included in this project because of (1) the high cost and reliability problems of thermodynamic systems and (2)the high cost of photovoltaic systems and likelihood that, without any Kenyan research or demonstration effort, cost will decline precipitously and reliability and other operating characteristics will improve in the years ahead.

An additional factor in community water supply systems is the potential for local manufacture. There currently are two commercial windmill producers in Kenya, both trying to establish themselves in this new and only slowly emerging market. Although virtually all hydrams currently are imported from one manufacturer in England, there has been limited experimentation with local hydram designs and conceivably could be future potential for local production.

6. Solar Drying

The primary economic benefits from solar drying are expected to be (1) reduction of storage, processing, and distribution losses and (2) ability to fetch higher prices for cash crops due to reduction of product contamination. In addition, tobacco or other large-scale users of firewood are concerned over future wood scarcity and are interested in solar drying as a means of both limiting future energy price increases and assuring energy availability.

7 Other Technologies

Biogas systems are not included in this report primarily because the combined capital costs of both the biogas system itself and the animals needed to keep it supplied with manure put it well beyond the reach of AID's target population groups. Similarly, power alcohol has not been included because of the high capital cost of even small-scale systems, and the lack of obvious non-beverage uses for such alcohol by the urban or rural poor. Both technologies also have fairly sophisticated operation and maintenance requirements.

D. ADMINISTRATIVE/INSTITUTIONAL FEASIBILITY SUMMARY

1. Introduction

There are several administrative issues or potential constraints which are critical to the success or failure of the project.

First, the Ministry of Energy is new, relatively small, and still in the process of developing both its policies and programs and its relationships with other ministries. Many other ministeries have ongoing operations which relate directly to the activities recommended in the project. The Ministry of Energy is in a position to play a technical advisory role for several ministries . However, experience with other programs suggests that interministerial cooperation is not easy. Both a formal interministerial coordination mechanism and close informal cooperation and mutual trust must be established.

In addition to interministerial coordination, coordination and communication lines must be kept open among the numerous donors which have initiated or are planning energy related projects.

Another critical administrative issue and a central component of the project is extension of the technologies to the poor. Many ministries, particularly the Ministry of Agriculture, have well-established extension networks. Still, while progress has been made, there are difficulties in reaching the poorest families that constitute AID's target groups.

2. Initial Planning and Surveys

Two administrative issues should be highlighted. First, this component requires that MOE work closely with the Ministries of Finance, Economic Planning and Development and others paralleling the major energy consuming sectors, such as Industry and Agriculture, in monitoring energy consumption and shaping national energy conservation policy.

Secondly, a multiplicity of donor efforts in providing planning assistance runs the risk of not only duplication but inconsistent or even contradictory advice.

3. Institutional Development

If it is to initate effective programs outside those areas where it already has ongoing programs (e.g., electric power), the MOE must work with and through those ministries who already have directly related programs. In some areas, non-governmental organizations also constitute important resources on which the MOE can draw.

Based on this role of MOE as an advisory and initiating organization working primarily with and through others, the project at least initially

will place the four long-term experts (afforestation/forest management, agroforestry, wood/charcoal conversion and end-use devices, and an expert in renewable energy water pumping systems) and short-term consultants in the MOE, with the understanding that most of their time will be spent working with other Ministries.

Pursuing such an advisor/initiator role poses risks for both MOE and the project. Operating ministries may spurn MOE offers of assistance, or they may be reluctant to direct their extension or other resources to energy from whatever they currently are working on. As in most other countries, in Kenya the power of a government organization generally is related to its size and the nature and scope of its operating programs. Over time, the MOE may become dissatisfied with an advisory role and try to launch its own operating program, for example in fuelwood. Should it do so, it is much more likely to be viewed by other ministries as competition, and its ability to work with or through them in other areas will suffer.

4. Applied Research and Development

Fuelwood/Agroforestry Centers

The project contemplates six fuelwood/agroforestry research, demonstration, and extension centers. Nursery operations and extension farms and communication are major components of the centers. Both MOA and MENR already have ongoing nursery and afforestation extension programs in all or most Districts. While they currently are not sufficiently extensive to satisfy all demand, they have demonstrated a capacity to expand and certainly represent a strong base on which to build. Particularly the MOA -- with the largest farmer extension program in Africa, a network of multi-purpose tree nurseries, and a strong interest in agroforestry as a soil conservation measure -- provides an excellent basis for the proposed centers.

Accordingly, it is intended that, wherever possible, rather than establish new operations, the MOE contract with the MOA and MENR to operate such centers with funds provided under the project. As in the case of extension, this project will require a substantially greater degree of interministerial cooperation than is required of most programs operating in Kenya. There are, however, examples of other cooperative programs and, in the case of the Rural Development Fund, for example, of both contracting with other ministries and transferring Authority to Incur Expenditures. The MOE appears willing to operate in this manner, and the appropriate organization within the Misistry of Agriculture supports the project concept and desires to participate on this basis. However, the risk of interministerial conflict, or simply inability to work effectively together does constitute a risk for this project component.

Energy Development Fund

The Energy Development Fund will require involvement of both other ministries and District or Divisional Development Committees to publicize availability of the Fund, encourage grant proposals, in some cases pr pare

proposals directly, and make funding recommendations to MOE. Again, the Rural Development Fund provides a model for such participation. The MOE and its long-term experts also will have to work closely with non-governmental organizations both to help develop and evaluate proposals for program grant funding and to encourage them to stimulate local project proposals. Finally, MOE will have to work closely with related funding sources, including the Rural Development Fund, the NCST research grant program, and the soon-to-be established Nairobi office of the VITA/AID Small Energy Grants program.

Grant administration is not viewed as a serious problem. The Fund is small and simple so that the MOE, with the assistance of the Energy Planning expert, should be able to establish straightforward procedures and to train the Fund staff.

Monitoring and Evaluation

Because this project is heavily oriented toward extension and institution-building and because of the degree of interministerial coordination required, monitoring will be both complicated and extremely important. It is proposed that, as interministerial agreements regarding operation of fuelwood/agroforestry centers are being negotiated, an AID team be sent in to develop a detailed monitoring plan. The team must include a sociologist/extension expert. Also, since some monitoring functions may have to be carried out by the ministries operating the centers, it is important that monitoring requirements be included in the interministerial contracts. The monitoring plan will provide the basis for annual project reviews, which should involve not only MOE and AID, but the other ministries involved. The team also will develop the plan for the midterm and final project evaluations, which again must involve the other ministries.

V. IMPLEMENTATION PLANNING

A. Administrative Arrangements

1. Government of Kenya - The primary GOK implementing organization will be the Ministry of Energy (MOE). The Office of the Permanent Secretary, MOE will assume responsibility for overall project performance. More specific responsibilities for individual project components, together with comments on implementation issues, are set forth below.

a. Initial Planning and Surveys. The Policy Monitoring and Planning Division, MOE will be responsible for all activities under this component. Within this Division, a full-time Planning Officer will be assigned to direct installation and operation of the AL-EDIS energy assessment system; a full-time Librarian will direct installation and operation of the Energy Data Bank and Library; and a full-time Senior Planning Officer will be assigned as counterpart to the long-term Energy Planning and Conservation Expert to be provided as part of this project.

The Policy, Monitoring, and Planning Division currently has four full-time professional staff members, of which two are economists seconded to the MOE by the Treasury. The Division has an approved 1980/81 budget level of eight professionals. Two current staff members have attended AID's Energy Management Training Program (EMTP) at SUNY Stonybrook and are familiar with the AL-EDIS system. One staff economist currently is assigned full-time to energy conservation and has been quite active, although energy conservation represents a new field for him.

Because economists and statisticians are seconded to MOE from the Ministry of Economic Planning and Development, it should be possible for MOE to build its staff in these specialities rather quickly.

Training will be required in operation and use of the AL-EDIS system (both attendance at the EMTP at Stonybrook and shorter courses conducted by EMTP ectures in Nairobi), in operation and use of the Data Bank and Library (presumably on-the-job training), and in energy conservation. The latter will be the most difficult, since there currently are no suitable short (8-12 week) courses covering the broad field of energy conservation. It may be advisable to develop a Nairobi workshop for Kenya only or, in conjunction with the AID REDSO, for East Africa to address specific East African energy conservation issues. The long-term Energy Planning and Conservation Expert and short-term consultants provided as part of this project would be the logical ones to develop and hold such a workshop.

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(1) MOE organizations are based on the "Proposed Structure of the Ministry of Energy", March 1980.

b. Institutional Development

The Fuelwood Extension Expert, Agroforestry Expert, Cookstove/Charcoal Expert, Wind/Water Extension Expert, and short-term consultants assigned under this project component all initially will be assigned to the Technical Division, MOE. The first three of the long-term experts together with related short-term consultants will be under the Charcoal and Firewood Section while the fourth long-term expert and related short-term consultants will work in the Non-Conventional Energy Section. It may be that as part of more detailed project implementation agreement with other Ministries (as discussed below), MOE will second the Agroforestry Expert to the Ministry of Agriculture.

Each long-term expert will work with a full-time GOK counterpart professional staff member - Conservator of Forest I or Assistant Conservator I or equivalent in the case of the Fuelwood Extension Officer and the Agroforestry Expert and an Engineer -- or, preferably, an extension specialist of equivalent professional level -- for the Wind/Water Extension Expert.

Implementation of this program component will be difficult. The MOE and its long-term experts and short-term consultants will have to carry-out the demonstration and extension components of the project largely through other Ministries -- particularly Agriculture, (MOA) and Environment and Natural Resources (MENR) for forestry; those two Ministries plus Livestock Development (MLD) for agroforestry; Water Development (MWD), MOA, Lands and Settlements (MLS), and possibly MLD for water supply and irrigation systems; and MOA, Culture and Social Services (MC/SS) and whatever Ministry ultimately is selected to house the Village Polytechnics for other areas of rural extension — and through non-governmental organizations. Experience with other programs suggests that achieving such close cooperation will not be easy. Moreover, as discussed in the analysis sections, achieving extension success will be difficult even with close cooperation.

A particular problem is that MOE has no budgeted positions for extension specialists. In fact, there is no such GOK personnel category, since field extension staff are shown as Agricultural Officers, Water Officers/Bailiffs, etc. It is recommended that the MOE use one of its six budgeted Non-Conventional Energy Engineer positions or a non-technical MOE position to recruit an engineer with District or Division level extension experience (for example, a District Water Engineer), and a female Home Economics or Women's Bureau extension specialist.

A very important aspect of this project component is provision of curriculum development and training support to Kenya training institutions. This will require that the long-term experts and short-term consultants and their GOK counterparts work closely with those institutions. Also, the experts and consultants and their counterparts should require from each such institution, prior to providing such support, written confirmation of how the institution intends to work such curriculum into its overall program and what support - in terms of teaching staff and materials, etc. - it will

provide. One of the early tasks of the long-term experts should be to work with Kenyan training institutions to develop mutually agreeable curriculum development implementation plans.

U.S. short-term technical/extension training at Gainesville or elsewhere or participation in Kenyan courses will be encouraged for the GOK counterparts and other MOE personnel, particularly those in the Non-Conventional Energy Section (but not limited to them). At the discretion of MOE, such training may also be provided to professionals in other Ministries who are working or are likely to work with the project on a continuing basis.

Procurement of vehicles and other U.S. source commodities under this and the Applied Research and Demonstration component, including procurement of tractors and equipment for the fuelwood/agroforestry demonstration and extension centers, will be carried out through a U.S. procurement services contractor such as is normally used by AID. Non-U.S. source commodities will be purchased through the MOE's normal procurement procedures.

c. Applied Research and Demonstration

(1) Fuelwood/Afforestation Centers: MOE will negotiate agreements with the MOA and/or MENR to provide land and operating manpower for and day-to-day operation and management of the fuelwood/afforestation centers described earlier. Other manpower required at each center (and particularly the two extension specialists) will be recruited and supervised by the Ministry operating the center, with funds provided under this project. Wherever possible, such centers will be based at existing nurseries operated by one or the other of these Ministries.

The MOE, more particularly its long-term Fuelwood Extension and Agroforestry Experts and counterparts, will provide overall policy direction and oversight of all the centers. The project also will provide, through MOE, training of center personnel and of the MOE counterparts. Such training will consist primarily of on-site on-the-job training. For the MOE counterparts, some center extension specialists, and possibly individuals in MOA or MENR who are managing the centers' operations, training also will include visits to successful agroforestry demonstration/extension projects in other African countries (e.g. Rwanda).

Agreements negotiated with MOA and/or MENR will include detailed implementation schedules, staffing plans, description of operating arrangements, and budgets for each center.

Within MOE, responsibility for this project component presumably will be assigned to the Charcoal and Fuelwood Section of the Technical Division.

(2) Energy Development Fund: With the assistance of the long-term Energy Planning and Conservation Expert, MOE will develop a Fund implementation plan to include detailed loan/grant application and selection procedures, selection criteria, and grant administrative, financial, technical, and program management procedures. MOE also will define the staffing to manage the Fund (to include, at a minimum, a suitable professional person with financial management experience) and organizational responsibility for the Fund. The Fund currently is designated as a separate section under the Administrative Division, MOE. It is presumed, based on discussions with MOE, that the organization and staff which manages the AID-financed portion of the Fund also will manage other donors' contributions to the Fund or other donor-supported R&D loan or grant projects.

As described earlier, specific project loan or grants (as opposed to broad program loans or grants) to organizations initially will be reviewed by the appropriate District Development Committee (DDC). Also, where a project involves the operations of another Ministry (for example, MWD for community water supply systems), that Ministry will be involved in the project review, at the District and if necessary Nairobi levels. The Fund implementation plan will describe how the DDC's and other Ministries are to be involved.

Every effort should be made to keep the loan/grant application, selection, and administration process as simple as possible while still providing reasonable assurance of sound project selection and a degree of financial and project accountability appropriate to the size of each loan or grant (under $75,000 for program loans/grants and under $15,000 for project loans/grants).

d. Monitoring and Evaluation: As described in more detail in the Monitoring and Evaluation section, the Energy Planning and Conservation Expert (who also will be the Consultant Team Leader) will work with his GOK counterpart and other consultant and MOE staff members to prepare an annual project monitoring report. This report will address progress in meeting schedule and cost obligations, technical and extension accomplishments, cooperation with other Ministries and with other donors; related programs, problems encountered, and recommended remedial actions. The report is intended both as a management tool for the MOE and its Consultant Team and as a means by which AID can track project progress.

By no later than December 1982, an independent evaluation team selected jointly by MOE and AID will have conducted a thorough mid-term project evaluation. By no later than the end of the sixth month preceding the Project Assistance Completion Date (PACD), the independent evaluation team will have conducted a thorough final evaluation of the project. MOE will assign a senior staff member to work with this evaluation team, to review its preliminary analysis and findings, and to review the draft mid-term and final evaluation reports with the evaluation contractor, project contractor, and AID.

2. AID

USAID/Kenya has necessary delegation of authority to implement this project. The project will be housed in USAID/Kenya's Multi-Sector and Engineering Division. In accordance with AID Policy Determination 140.68, AID will implement the project through a host country contract. MOE is prepared to commit the management resources necessary to carry out its responsibilities under such a contract. USAID will be provided various work plans and other documents for its review, as discussed in the Conditions Precedent Section , and will participate in both the annual project progress review and periodic MOE-donor meetings held to review all donors' energy assistance projects. It also will select (jointly, with MOE) the outside organization to conduct the mid-term and final project evaluations and will review, with MOE and the project contractor, that organization's findings.

B. Implementation Schedules

The preliminary project implementation schedule is presented in Table V-1. Specific work elements are briefly discussed below.

1. Assistance to Beijer Project. The Beijer Institute intends to commence its Fuelwood Cycle Project in October 1980. AID's portion -- installation and use of the AL-EDIS system and related training and computer hardware and software -- will be provided through a sole source contract or PASA to engage the Institute for Energy Research (IER), SUNY Stonybrook, developer of the AL-EDIS system. Initial AL-EDIS training will be provided by IER in the U.S. and Nairobi, since the next session of the IER Energy Management Training Program is not scheduled to commence until Spring 1981. The schedule presented herein could change due to delays in other donors' commitment of their portion of funding for the Beijer project, delays in signing a contract or PASA authorizing IER to proceed, or normal adjustments in Beijer's project schedule once it commences work. In particular, the timing of this must be flexible enough to respond to changes in the timing and direction of the overall Beijer project of which it is a part.

SUNY Stonybrook is uniquely qualified to perform this task since it is developer and owner of the AL-EDIS system, which has been specified by name by MOE/Beijer. Stonybrook has trained two of MOE's four planners, using AL-EDIS for training purposes, and already has entered preliminary Kenya energy data into the AL-EDIS system.

2. Beijer Implementation Planning Assistance. GOK will be given authorization to negotiate and add-on to its Fuelwood Cycle Project contract with the Beijer Institute, not to exceed $100,000, to assist the MOE on this project to prepare more detailed implementation plans and

finalize project implementation arrangements. Beijer particularly will assist the MOE in implementation planning for the fuelwood/afforestation centers project component. Beijer will assist in site identification and selection, species/seed identification and selection, preparation of site-specific cost estimates and implementation plans, and MOE-MOA and MOE-MENR negotiations. Additionally, within the limits of the contract amount, MOE at its discretion may have Beijer provide other project implementation planning assistance, such as preparation of preliminary Energy Development Fund procedures and criteria.

Under a separate contract, AID will prepare a feasibility study and preliminary implementation plan for a fuelwood/agroforestry demonstration and extension center in Kitui District. This study will provide a prototype which may be used, for costing and implementation planning purposes, for all six centers. The Kitui study will be completed before Beijer begins its implementation planning assistance under this project.

Beijer is uniquely qualified to provide this service since its Fuelwood Cycle Study addresses many of the issues which must be addressed to establish the fuelwood/afforestation centers. Its staff will comprise the only forestry and forest economics expertise within MOE, and it will be providing closely related fuelwood planning and program implementation assistance to MOE in any case.

3. Contract for Technical Assistance and Related Materials and Equipment. MOE will prepare an RFP soliciting bids from qualified U.S. and Kenyan firms to furnish all technical assistance and related materials and equipment to be provided under this project, with the exception of the assistance provided under the preceding two work elements. The RFP will encourage liberal use of Kenyan consultants where possible.

4. Fuelwood/Agroforestry Demonstration, Training and Extension. This work element encompasses both the fuelwood/agroforestry demonstration/extension centers and related training and extension assistance to be provided under this project. Tasks shown under "Preliminary Period" are to be carried out as part of the Beijer implementation planning assistance described above.

5. Other Renewable Energy Training and Extension. This element includes the work of the long-term Cookstove/Charcoal and Wind/Water Extension experts and associated short-term consultants. This schedule is meant only to be illustrative. Both the nature and timing of specific tasks are likely to change substantially as the MOE refines its thinking in the months prior to contract award and as the contractor team, with its own views on how best to carry out training and extension work, arrives.

6. Energy Development Fund. This schedule presumes that work will not commence on the Fund until after award of the technical services contract. Were the MOE and/Beijer to prepare preliminary procedures and criteria earlier, the Fund could be established well in advance of the dates shown.

7. Monitoring and Evaluation. Annual progress reports will be prepared by the consultant team working in conjunction with MOE. The mid-term and final evaluation reports will be prepared by an outside organization selected by AID and MOE.

C. Other Implementation Arrangements

1. Initial Implementation Planning. Establishing effective cooperative demonstration and extension processes is critical to the success of the project. It therefore is envisioned that, as one of the first and highest priority tasks following MOE award of the technical assistance contract, the MOE, contractor, and AID would engage in a collaborative implementation planning process. This process preferably would be conducted through a series of interactive planning workshops which may stretch over a period of several weeks. The process should integrate all aspects of the project -- fuelwood and afforestation, cookstove development, etc. -- and involve, at appropriate points, the major groups that will have to carry out important aspects of the project. These groups include, at a minimum, MOA, MENR (Forest Department), MOL (Village Polytechnics), MCSS (Women's Bureau and DO's), and at least one or two NGO's (the NCCK is suggested). Short-term consultants who are expert in participatory planning processes should also be used to establish and monitor the process.

The parametersof this implementation process purposely have been kept general in order to allow the contractor, once selected, and MOE to work out, with AID, a planning approach with which they feel comfortable.

2. Contracting Arrangements and Waivers. It is presumed that this project will be implemented via PD-68 contracting procedures applied by AID for host country contracting, as stipulated in Handbook 11 "Country Contracting". Thus, for example, solicitation of technical proposals, analysis of the proposals, and final selection will be conducted by the GOK with USAID/Kenya assistance.

As provided in PD-68 and recommended in a worldwide audit request on Host Country Contracts prepared by the AG, dated May 18, 1979, USAID will assess the ability of the Ministry of Energy to implement a Host Country Contract. Should it be determined that MOE does not have such ability, USAID will provide the technical assistance stipulated in this project under a PASA or direct contract arrangements. Initial indications, however, are that MOE is capable of implementing a Host Country Contract.

Sole-source contracts will be authorized for provision (through SUNY Stonybrook) of AID's portion of funding for the multi-donor Beijer Institute Fuelwood Cycle Project and for an add-on to the GOK-Beijer contract to provide the MOE with Fuelwood/Agroforestry Demonstration Center implementation planning assistance. Beijer is a non-U.S. non-profit institution affiliated with the Royal Academy of Sciences in Sweden.

One vehicle of non-U.S. manufacture -- a Land Rover assembled in Kenya -- will be provided under this contract. Seeds of genera or species unavailable elsewhere and selected publications for the Energy Data Bank and Library will be procured from outside the U.S. or Kenya. Some materials and supplies for the fuelwood/agroforestry or other extension work will be purchased locally and are likely to be of non-U.S. manufacture. The prices of all non-U.S. commodities represents less than ten percent of USAID's contribution.

Up to $25,000 of participant training may be conducted in third countries. In all cases, these will be other African countries.

No other waivers are involved in the procurement of services and commodities for this project.

2. Logistic Support

The Project Grant Agreement between the GOK and USAID stipulates that the GOK shall provide the long-term technical assistance team free of charge with "such offices, secretaries, administrative assistance, equipment and facilities and transportation as are necessary for them to perform their professional services. Such assistance shall include three stenographer/typists, Grade II or above, two drivers and one messenger,and office equipment,including four executive desks and desk chairs, three secretarial desks and chairs, seven bookcases, three electric typewriters and seven telephones". Within the project, funds are provided for housing, travel and transportation, shipping and storage, procurement of project vehicles, and payment for cables, postage and other miscellaneous office expenses. The Project Grant Agreement also calls for the usual duty-free privileges extended by the GOK to foreign technical assistance personnel.

D. Evaluation Arrangements

As noted in the Implementation Schedule, a mid-term evaluation is scheduled to be completed by December 1982 and a final project evaluation is scheduled to be completed not later than six months prior to the PACP, or by March 31, 1984. The mid-term and final evaluations will be conducted by a disinterested organization selected jointly by USAID/Kenya and acceptable to the GOK.

The specific basis for the project evaluation will be the project's Logical Framework, Implementation Schedule and subsequent detailed contractor work plans, and the detailed evaluation plan to be developed by an AID team early in the project, as outlined in Chapter VI and subsequently modified and jointly agreed to by the GOK and USAID/Kenya.

For further information on the USAID/Kenya evaluation system, including responsibilities and procedures, see USAID/Kenya Mission Order 10-3, dated March 21, 1975.

TABLE V - 1. PROJECT IMPLEMENTATION SCHEDULE

Timeline	Project Activity	Responsible Organization
I. INITIAL PLANNING AND SURVEYS		
A. AL-EDIS:		
Aug. 80	Sign Project Agreement	GOK/AID
Sept. 80	Initiate AL-EDIS Procurement Action	AID
Oct. 80	Initiate Beijer Fuelwood Cycle Project	MOE/Beijer
Oct. 80	Sign AL-EDIS Contract	AID
Nov. 80	Initiate Computer Equipment Procurement Action	Stonybrook
Feb. 81	Install Equipment, Complete Reprogramming	"
Mar. 81	Initial AL-EDIS Assessment Runs Completed	"
Mar. 81.	In-Country Training Completed	"
Apr. 81	Final AL-EDIS Report, Beijer Workshop	", Beijer/MOE
B. Technical Assistance:		
Oct. 80	Draft Tech. Assistance RFP Prepared	MOE
Dec. 80	RFP Released in Kenya and U.S.	MOE, AID
Feb. 81	Contractor Proposals Received	--
Mar. 81	Tech. Assistance Contract Award	MOE
May 81	Long-Term Experts Arrive In-Country	Contractor
May 81	MOE, With Contractor, Specifies Short-Term Consultant Needs and Timing	MOE, Contractor
June 81	Short-Term Consultants Arrive In-country	Contractor
Oct. 81	Energy Survey/Information Systems Designed	MOE, Contractor
Nov. 81	Preliminary Energy Policy Analyses and Recommendations	Contractor
C. Energy Data Bank and Library:		
July 81	Data Bank and Library Materials Assembled in U.S.	Contractor
Sept. 81	Data Bank and Library Established in MOE and Librarian Trained in Its Use	"
II. INSTITUTIONAL DEVELOPMENT		
A. Fuelwood/Agroforestry:		
Aug. 81	Negotiation of training/curriculum development implementation plans for Farmers Training Centers, Forest Training Centers, Agric. College /Institutes, Univ. of Nairobi, Facilities, of Agriculture and Forestry	Contractor MOE, MOA, MENR
Aug. 81	Negotiation of extension/coordination arrangements with MOA, MENR	MOE, Contractor
Oct. 81	Negotiation of assistance implementation plans with NGO's (NCCK, NCKW, etc.)	MOE, Contractor NGO's

Timeline	Project Activity	Responsible Organization
Nov. 81	Survey of District fuel wood/agroforestry programs completed	Contractor MOE/Beijer
Mar. 82	Beijer Fuelwood Cycle Project Completed	MOE/Beijer
Mar. 82	Training programs at formal training institutions in place, NGO workshops held	Contractor MOA, MENR, NGO's
June 82	Assessment of feasibility of Fuelwood Production near Nairobi completed	Contractor

B. Cookstoves

Aug. 81	Negotiation of extension/coordination arrangements with MOA, MCSS	MOE, Contractor
Aug. 81	Negotiation of training/curriculum development implementation plans-- KIA, Farmers Training Centers, Village Polytechnics, Agric. College/Institutions, Karen VTU	MOE, Contractor,
Oct. 81	Negotiation of stove development/testing and extension assistance implementation plans with NGO's in Kenya(NCCK, Peace Corps, etc.) and/or outside orgs. (Ap. ITDG, etc.) (Aprovecho, ITDG, etc.)	MOE, Contractor
Oct. 81	Informal survey of urban/rural cookstove use and development completed	Contractor
Dec. 81	Training tour of African cookstove development programs completed	MOE, Contractor
Feb. 82	Dissemination of extension information brochures for Home Economics Officers, Community Dev. Officers and Assistance	Contractor
Mar. 82	Formal training and stove development/ testing programs in place, workshops held	MOE, Contractor
Sept. 82	Prototypes developed, field tested; Follow-up program in place	MOE, Contractor
Nov. 82	Long-Term Expert Departs	Contractor

C. Charcoal Production:

Aug. 81	Negotiation of extension/coordination arrangements with MOA, MENR	MOE, Contractor
Aug. 81	Negotiation of training/curriculum development implementation plans -- Agric. College/Institutes, Institutes of Technology, Village Polytechnics, Farmers Training Center, Forest Training Centers, Karen VTU	MOE, Contractor
Oct. 81	Negotiation of Charcoal kiln development/ testing and extension assistance implementation plans with NGO's (NCCK, PFP, etc.)	MOE, Contractor
Oct. 81	Informal survey of charcoal production methods completed	Contractor
Dec. 81	Analysis of alternative national charcoal production strategies completed	MOE/Beijer, Contractor
Mar. 82	Formal training and development/testing programs in place	Contractor

Timeline	Project Activity	Responsible Organization
Mar. 82	Dissemination of extension information brochures for Agricultural Officers, District RAES Officers	Contractor
Nov. 82	Long-Term Expert Departs	Contractor
D. Community Water Supply and Irrigation:		
Aug. 81	Negotiation of extension/coordination arrangements with MWD, MOA, MLS, MLD	MOE, Contractor
Oct. 81	Review of MWD water supply plans and joint development of project review criteria completed	MWD, MOK Contractor
Oct. 81	Informal survey of District Water systems completed	Contractor
Dec. 81	Review of non-MWD water supply plans completed	Contractor
Dec. 81	Wind measurement devices in place	MOE, Contractor
Feb. 82	Dissemination of extension/project review information brochures for District Water Engineers, Harambee groups	Contractor
Nov. 82	Long-Term Expert Departs	Contractor
III. APPLIED RESEARCH AND DEMONSTRATION		
A. Fuelwood/Agroforestry Centers		
Oct. 80	Kitui nursery/extension center feasibility study completed	(separate contract)
Oct. 80	Contract award to Beijer for Center implementation planning	AID
Jan. 81	Site selection and detailed cost estimates and implementation plans, approved by operating ministries, completed	MOA, MENR
Feb. 81	Seeds/germ plasm identified and ordered	MOE/Beijer
Feb. 81	U.S. equipment ordered	AID-Proc. Services Contractor
Mar. 81	Initiation of site preparation	MOA, MENR
Mar. 81	Initiation of center staff recruiting and training	MOA, MENR
June 81	Revisions to Center demonstration/ implementation plans, if required	MOE, MOA, MENR, Contractor
June 81	Completion of arrangements for local farmers' demonstration plots	MOA, MENR
Sept. 81	Commencement of Center nursery demonstration and extension operations	MOA, MENR
Feb. 82	Initial assessment of results and plan revision	MOA, MENR, MOE Contractor
June 83	Preparation of preliminary implementation plan for expanded fuelwood development and agroforestry	MOE, Contractor

Timeline	Project Activity	Responsible Organization
B. Energy Development Fund:		
May 81	Fund staff hired	MOE
June 81	Draft procedures and criteria, with agreement of DDC's, others involved	MOE, Contractor
July 81	Publicize fund -- Meeting with NGO's, DDC's, other ministries	MOE, Contractor
Aug. 81	AID commitment of funds	AID
Sept. 81	Initial applications received	MOE, DDC's
Oct. 81	First year loans/grants awarded	MOE
Oct. 82	Second-year loans/grants awarded -- first evaluation of existing projects completed	MOE
Oct. 82	Third-year loans/grants awarded -- second evaluation of existing projects completed	MOE

IV. MONITORING AND EVALUATION

July 81	Detailed Monitoring and Evaluation Plan Completed	AID
Oct. 81	First Annual Project Report/Review	MOE, Contractor
Oct. 82	Second Project Report/Review	MOE, Contractor
Dec. 82	Mid-Term Project Evaluation Report	AID
Oct. 83	Third Project Report/Review	MOE, Contractor
Mar. 84	Final Project Evaluation	AID
Sept. 84	Final Project Report/Review	MOE, Contractor

VI. EVALUATION PLAN

A. General Requirements

Since most renewable energy technologies are still in the demonstration and dissemination stage, it is important that they be evaluated for their sociological, economic and technical feasibility and potential for wider distribution, rather than their impact on the well-being of the community, during the first few years.

USAID will provide a team of 2-3 evaluation experts for 2-3 weeks to prepare a detailed project monitoring and evaluation plan. The plan will address compilation of baseline data; annual project progress reporting; ongoing feedback monitoring and evaluation of the extension assistance, fuelwood/agroforestry center, and Energy Development Fund components; and the mid-term and final project evaluations. The team must include a sociologist or rural extension specialist. It is recommended that the team be provided by AID/W (PPE) and include at least one PPE staff member.

The first part of the monitoring and evaluation plan should consist of a system of ongoing internal monitoring, evaluation and feedback. Provision should be made for periodic data gathering, problem identification, and project modification as necessary. For each of the technologies a series of sociological, economic and technical questions which must be answered should be developed. (Examples begin on VI-2). These questions can be answered by means of a questionnaire, participant observation, group discussion interviews or having a field officer keep a journal. The project experts will be responsible for conducting or overseeing this activity.

For the nursery extension centers, periodic site visits should be made by the forester and agroforester. The director of each center should keep a journal, particularly to record problems that arose which required a modification of the program. The center extension agents should also provide for periodic "evaluation" by holding feedback meetings with interested farmers or other means to determine the successes and failures they have experienced.

The Energy Fund will be much more difficult to monitor since the activities will not be directly implemented by the Ministry of Energy. However, some means must be established for monitoring and evaluating the projects funded. First, all program grants should require the submission and approval of an evaluation plan. Assistance in formulating these plans can be provided by the project experts, through workshops or individual discussions. Also, these organizations should be required to submit program/project status reports at least quarterly. Project monitoring and evaluation should be performed either by the MOE but preferably by a local extension agent which is assisting the group. Periodic on-site visits should be made by MOE.

Secondly, the project manager will be required to submit an annual report prepared in cooperation with the MOE. This report will address progress in meeting schedule and cost projections, technical and extension accomplishments, cooperation with other Ministries and donors and related programs, problems encountered and remedial actions. This report is intended both as a management tool for the MOE and the consultant team and as a means by which AID can trac progress of the project.

By the fifteenth month following arrival of the long-term experts, an independent evaluation team provided by the AID Mission and acceptable to the MOE will conduct a mid-term project evaluation.

Finally, no later than the end of the sixth month preceding the Project Assistance Completion Date (PACD) an independent evaluation team will have conducted a thorough evaluation of the project. MOE will assign a senior staff member to work with this evaluation team, to review its preliminary findings, and to review the draft and final evaluation reports [illegible] evaluation [illegible], project contractor and USAID.

In each area of renewable energy use the long-term experts, with the assistance of the short-term consultants, should conduct a survey and assessment of existing conditions, including current projects and activity. In the case of forest resources, they should work with the Beijer project to use existing Remote Sensing Center, Geosurvey and Survey of Kenya data supplemented by ground checks to estimate both present resources and recent deforestation rates by region. For energy consumption data, to the extent possible they should use CBS survey data already compiled, and where necessary support the CBS to conduct additional surveys or incorporate energy modules into existing surveys, so that baseline data can be compiled as soon as possible.

B. Data Collection and Analysis*

Finely detailed or specific data categories can only be developed with a particular project in mind. For example: the socio/cultural factors relevant to use of a solar cooker will be different than those of a village wood lot. Below is a discussion of a set of data categories and their sub-elements that are non-specific in terms of particular renewable technologies but which can be adapted to the specific technology and local setting of the project.

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* Excerpted from "The Role of Evaluation for Renewable Energy Project in Africa", by George Burrill, November 1, 1979, Burlington, Vermont, U.S.A.

Technical

--Adequate physical data (amount of biomass, wind, solar, etc.) should be gathered to verify the original assumptions or estimates made during project design.

--Complete records of component acquisition in person hours, costs, and skill requirements.

--Complete records of technology installations in person hours, costs, and skill requirements.

--Complete records of system output.

--Complete records of system performance, down time, maintenance activities and costs.

--Records on environmental impacts.

--Changes that could be made, for example, in:

overall system design

component acquisition

local manufacture of technology

system maintenance

Information can then be assembled on the potential technical effects of such changes on the system.

Social/Cultural

--Relationship of the energy project and technology to the users or to village daily and seasonal life patterns. Also, data on behavior changes required by the technology, and on villagers' traditional habits or ways of doing things which are affected by the project, although not necessarily required to change by the technology (i.e., behavioral side effects).

--People's attitudes towards the technology and the project.

--Behavior of organizations in the project.

--Other cultural constraints discovered during the project that were not identified by the project planners.

--Data on performance of the project's ownership strategy and maintenance strategy from a social/cultural standpoint.

--Equity results of the project as implemented:

impact on male and female roles

impact on local income level groups

impact on ethnic sub-groups and castes

related to individual vs. family vs. community

Economic and Financial

David French has suggested the following elements:*

--Value of a system's output (if measurable in market prices).

--Alternative employment opportunities (to measure benefits if the system chiefly releases labor from former tasks).

--Costs of site preparation and installation of the system.

--Direct operating costs.

--Degree of local unemployment (to find shadow wages).

--Existing uses of raw materials (to find their shadow price).

--Extension costs of introducing the system.

--Market interest rates for local borrowing (to estimate investors' discount rates).

--Characteristic local investments (to suggest willingness to take financial risks).

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* French, David, "The Economics of Renewable Energy Systems for Developing Countries", US/AID, Washington, D.C., January 1979.

ANNEX A. TECHNICAL ANALYSIS

I. FUELWOOD/AFFORESTATION

A. Wood Supply and Demand

A striking feature of the wood fuel situation in Kenya is lack of data on the production, and to a lesser extent, the consumption side. The extent and productivity of natural and planted tree vegetation is largely unknown, as are patterns of land ownership use -- which would provide some indication of future wood fuel production potential.

Ecological Zones

Kenya covers a land surface of approximately 570,000 km^2. Kenya can, with respect to conditions for tree growth, be divided into a large number of ecological zones (and subzones). Simplifying greatly, the highlands, where the majority of the population is concentrated, are characterized by a cool and relatively humid climate and, what is of great importance, by well structured volcanic soils of high fertility and generally excellent properties for supporting plant growth. A high density of population is also encountered on a narrow strip of land along the coast. Soils there are variable, from acid sands to clays derived from coral rock. Temperatures are high with only small fluctuations. The southern part of this strip receives a good rainfall, but north of Malindi the precipitation drops abruptly.

Between the coast and the highlands, the ecological conditions are affected by the annual precipitation, the elevation above sea level and the structure and depth of soils. At a short distance from the coast, the rainfall drops to low levels and conditions are very arid. Afterwards the precipitation increases with increasing elevation. However, the productivity of the land in terms of agricultural or forestry production is to a large extent a function of the soil structure. Where the soil is deep and well drained and aerated, trees grow well and the land is attractive to farmers wherever the rainfall gets above 700-800 mm. per annum. The larger part of the areas located at low and intermediate elevation (up to 1500 meters), is however, characteristically covered by compact, poorly aerated soils of low potential for any use except extensive ranching.

In the Western part of the country, particularly favorable ecological conditions, and a corresponding high density of population, are found along the shores of Lake Victoria. As one moves inland and uphill, conditions gradually change towards those of the highlands.

By far the greatest area in size is constituted by the thinly inhabited, semi-arid and arid northern regions to which may be added, as an ecological extension, the plains of the Rift Valley, stretching all the way down to the Tanzanian border.

Current Situation

Most sources estimated that Kenya's forests amount to roughly 1.7-2 million hectares (17-20,000 km^2), roughly 4% of the country's total area but (because most of its forests are located at higher elevations) some 15-16% of Kenya's medium to high potential land.[1] By this presumably is meant the areas of dense evergreen and semideciduous forest. This may understate the total forest cover, since trees -- and, equally important in marginal areas, savannah woodlands -- are found in quantities outside traditional "forest" areas.

Estimates of annual woodfuel consumption range from 10 to 25 million tons, or 15-36 million cubic meters, of roundwood equivalent per year. To this amount must be added wood consumption for other purposes. The World Bank estimates annual production of industrial raw timber and pulpwood to be roughly 1-1.5 million cubic meters of roundwood equivalent. Wood consumption for bomas, poles, etc. is unknown.

Except for Kenya's forest plantations (roughly 150,000 hectares), forests are not managed on a sustained yield basis. In fact, most highlands gazetted reserves are maintained as natural forest, with little or no production, for soil conservation purposes. For the average of all forest area, sustainable yields are unlikely to exceed $3m^3$/hectare, which would imply annual sustainable production of only 5-6 million cubic meters, far below demand.

A visual survey of environmental conditions indicates that, particularly on marginal lands currently undergoing rapid population expansion and areas near major urban centers, wood removal far exceeds the sustainable productivity of the vegetation. The removal of vegetative cover due to increased wood consumption or to intensified land clearing for legal or illegal agricultural settlement -- followed in many cases by excessive cropping or grazing -- has caused severe soil erosion, diminished water quality, and caused premature river and dam siltation and other impacts.

At lower elevations, where population densities historically have been low, rapid population growth and consequent intensifying land competition have forced migration onto and settlement of marginal, ecologically fragile lands. In most cases, these areas were populated only by random pastoralists as recently as 10-25 years ago. The resulting land clearing of protective trees and shrubs, to prepare land for cultivation and to produce wood fuel and construction timber, has caused severe soil erosion. On unprotected steep slopes in Machakos District, for example, farms are literally being washed away less than five years after settlement.

The Beijer Institute concludes that "...while it is not justified to draw sweeping conclusions from the information available, it appears that the country may be just now in the process of undergoing a change from a relatively adequate (wood) supply situation to a severe depletion of its forest resources."

[1]Land receiving more than 850 mm annually, considered the minimum needed to support agriculture on a continuing basis.

Future Demand and Supply

Whatever the current consumption level, the projected doubling of the population (from 15 million to over 30 million persons) by the year 2000 and continued migration from rural to urban areas (which has entailed higher levels of energy use) suggest that, within twenty years, the requirement for woodfuel will be 2-2.5 times present levels, or 45-60 million m^3 annually.

In order to produce such an amount of wood fuel on a sustained yield basis, 15-20 million hectares (or 150,000 - 200,000 km^2) of natural forest and woodland would have to be set aside and managed for the specific purpose of wood fuel production. Alternatively, the same production could be obtained from forest plantation[1] with fast-growing species covering 3-4.5 million hectares (30,000-45,000 km^2) established on relatively fertile land enjoying a fairly plentiful rainfall (800 mm). This represents 35-50% of all such land in Kenya. There is absolutely no likelihood of Kenya's being able to dedicate this percentage of its high-productivity land at the same time that agricultural output must be more than doubled. A third alternative therefore must be to integrate trees into large and small scale agricultural operations in ways which increase both wood and food/crop production. The sheer magnitude of projected wood fuel and food requirements suggests that such "agroforestry", as well as what we normally think of as "forests", must become a prime source of wood in future years.

Even with greatly expanded afforestation, improved management of forest resources, and widespread adoption of agroforestry techniques, Kenya will not be able to sustain a level of wood fuel consumption double present levels. Therefore, efforts to expand sustainable wood production must be viewed as complements, not alternatives, to measures to use wood more efficiently.

B. Options for Meeting Future Woodfuel Demand

Trees may be artificially established, or natural tree vegetation managed, for the purpose of fuel production within four distinct settings: government reserves, industrial plantations, communal lands, and private farms. In the last two cases, trees may be planted within regular dense plantations, mainly on marginal land, or integrated into land set aside for crop farming and/or pasture, within integrated agroforestry systems.

Forest Reserves

GOK gazetted forests cover approximately 1.7 million hectares and are made up predominantly of indigenous forests, with some exotic softwood and hardwood plantations (approximately 150,000 hectares). Virtually all forest reserves are located on productive soils, predominantly in the central and western highlands, and serve primarily as sources of raw timber or pulpwood. Present yields are $17m^3$/hectare for saw timber and $13m^3$/hectare for pulpwood on a thirty-year basis on the Forest Department's most productive plantations. Only a small proportion of the country's total fuelwood--

[1] World Bank project assessment, 1978.

13% according to a 1976 Forest Department survey and less than 10% according to Western Semekula-- comes from government forest reserves. However, there is substantial scope for increasing fuelwood production from such reserves through adoption of multiple-output management techniques.

As an example of what is possible, one can compare the difference in yield between a private industrial plantation forest in Malawi and a typical GOK highland forest reserve:

> The forest in Malawi is composed entirely of Eucalyptus plantations (Eucalyptus saligna). The annual yield may be on the order of 40m³/ha, converted into 10m³ of timber (boards, plywood and laminated beams) and 30 m³ of fuelwood.
>
> The typical GOK highland forest reserves is planted with Cupressus lusitanica and Pinus patula, with an average yield of less than 20 m³/ha, which in the sawmills (most of which are very small[1]) are converted into less than 10 m³ of sawn timber and over 10 m³ waste of a relatively poor quality.

This example does not imply that Kenya should stop producing softwood timber in order to increase the production of Eucalyptus firewood. Rather, the usefulness of the plantation forests could be increased if species and management practices permitting high yields of multiple forest products were introduced. The World Bank has financed two industrial (saw timber and pulpwood) plantation projects. The Bank is considering a third industrial forestry project but is not yet committed to proceeding. The project, if it does go forward, would include a fuelwood component of unknown scope and direction. It is unclear whether management practices to permit multiple-product (saw timber/pulpwood and fuelwood) harvesting might be included.

The forest reserves occupied by natural forest vegetation pose a very different problem. Several of these forests are at present disintegrating at an alarming rate due to settlement by "squatters". With the pressure for farmland growing incessantly, squatter settlement has become an important vehicle for acquiring a small plot for subsistence agriculture. It has become administratively and politically difficult to stop squatters from entering forest reserves. At the same time, these forests constitute important water catchment areas. Their destruction is endangering the water supply below, leading to the premature silting of dam sites, and threatening unique faunal and floral ecosystems.

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[1]The World Bank reports that, of 180 sawmills (producing 100,000 m³ of sawn timber annually), only five plants have a capacity in excess of 3000 m³ per annum.

It is unclear what options for dealing with the squatter problem would be both effective and politically acceptable. The traditional African "Taungya" system of periodically rotating settlements within the forest reserves potentially could at least lessen the damage. Alternatively, artificial plantations separating existing farmland from the areas of natural forest that need protection may constitute an effective barrier to encroachment. Squatters are less likely to run the risk of clearing well managed tree plantations, and the remaining natural forest would be isolated from settled land by a 3-5 kms deep buffer zone. The planting and upkeep of large forest plantations also would provide total employment opportunities, perhaps lessening squatter pressures.

Private Industrial Production

The only large private forest plantation in Kenya is the East African Tanning Extract Company (EATEC) black wattle plantation near Eldoret. In addition, farmers throughout the highlands have planted this tree, which has the advantage of being able to be direct-sown, as a cash crop. Although the main purpose of growing black wattle is the production of bark for tanning extract, the remainder of the tree constitutes an important source of high quality fuelwood for conversion to charcoal. However, even with what planting has been elicited, Kenya's two tanning extract plants reportedly are unable to produce at capacity because of insufficient black wattle

Eucaplyptus trees for fuelwood production have been planted on a considerable scale outside GOK forest reserves, as a result of private initiative and the efforts of the Forestry Department and some non-government organizations. Despite these efforts, however, production and marketing of fuelwood on a commercial scale from private land has not become widespread.

Major fuelwood consuming industries such as tea and tobacco (which use an estimated 150,000 m^3 and 300,000 m^3, respectively) are experimenting with afforestation programs. British American Tobacco (BAT) has established six nurseries to supply roughly 325,000 seedlings per year to small-scale tobacco farmers, with money for the seedlings lent by BAT and then repaid out of tobacco earnings. The major tea plantations currently rely primarily on fuelwood from their own estate fuelwood plantations. However, they are under growing pressure to convert such lands to tea planting and in a number of cases have requested that fuelwood be supplied from gazetted forests.

The Government of Kenya apparently without much success, is trying to encourage both the pulp/paper mill and the particle board mill to substitute trimmings, under-sized wood, and wood wastes for roundwood in their production processes. Such substitution would release roundwood for other uses.

The above examples suggest that private producers currently believe the incentives are to get out of--not into--production of wood for fuel or other

uses. However, experience in other countries -- and experience in Kenya with black wattle-suggests that industrial plantations and large- and small-scale farmers will respond to price incentives to grow trees. Current Forest Department stumpage prices appear to be too low to enable profitable private production. The scope for expanded private production and incentives necessary to elicit such production should be investigated. Also, contracting for private management of selected forest reserves should be considered.

Communal and Individual Forestry

The AID Design Team observed that there is land available even in the densely-settled parts of Kenya that could be employed more profitably for growing trees than for anything else. Examples of this category include:

- Stony, rocky land where underground fissures nevertheless make deep root penetration possible;
- Slopes so steep that they would be seriously exposed to erosion if farmed or trampled by cattle;
- Sloping areas where the soil previously has been exhausted and the land invaded with Lantana thickets;
- Areas characterized by seasonal water logging, assuming that suitable species are selected and planting is carried out on raised mounds or ridges;
- Highlands areas covered by heavy clays that presently carry only low-yield pasture and isolated trees, if sub-soiling or other techniques are used; and
- Semi-arid areas which can support only silviculture, generally combination fuel-fodder plants.

Communal Lands

Planting on communal land potentially offers great opportunity for the large-scale establishment of fuelwood or multi-purpose tree plantations. Most County Councils have designated land specifically, for afforestation. A 1979 Forest Department survey identified over 91,000 hectares of designated afforestation lands in 9 districts, with all but one district (Samburu) having designated at least 800 hectares.[1] In addition, administrative sub-locations (particularly in marginal areas where damage from soil erosion is already visible), churches, schools, and other groups appear to be setting aside land for afforestation projects. NGO's such as the NCCK and NCWK have launched community tree-planting programs and publicity campaigns which have been well received.

Abinga,"Wood Fuel Survey 1979-1980," Forest Department, p.21, the results are skewed by Marsabit's designation of over 67,000 hectares, presumably due in part of the IPAL project.

A later section describes the rural afforestation activities of various government and non-governmental organizations. In general however, it may say that:

- With the possible exception of the Ministry of Agriculture, other organizations (the Forest Department and NGO's) work primarily with community tree-planting groups rather than with individual farmers,

- There generally are too few nurseries, particularly in arid and semi-arid areas(which also suffer from a lack of seeds appropriate to these areas); and, more seriously,

- Whether because of lack of technical information/ assistance or lack of incentive, community groups fail to provide adequate post-planting maintenance and as a consequence generally have very low seedling survival rates.

A survey is required to ascertain how much land within this category has a potential for forest development. In addition, difficult issues regarding communal rights and responsibilities and incentives must also be addressed. Who would do the planting, who would ensure the silvicultural upkeep, and to whom would the output belong? A promising approach to clarification of such issues is offered in Marilyn Hoskins' proposal for formal community woodlot contracts.[1]

Individual Farmers

Close to centers or in the case of trees with commercial potential, it is possible that fast-growing trees in some cases could constitute a more profitable crop than grains even on very good farmland. Such a situation has arisen and been taken advantage of by farmers around several Ethiopian towns, including Addis Ababa. However, in general until adequate incentives are provided, planting of trees or the maintenance of natural tree vegetation on pasture or farmland will be acceptable only if the trees help to enhance food production in addition to their wood-yielding function.

[1]Marilyn W. Hoskins, "Community Participation in African Fuelwood Production, Transformation, and Utilization," ODC/AID,1979.

By utilizing many varieties of leguminous trees for fuelwood production, the potential exists for development of a combined agricultural-forestry production system. The mixture of tree species is critical to any agroforestry system. Multi-use trees which combine firewood, fodder and soil enrichment attributes potentially can increase crop yields to the farmer as well as contributing to general improvement in soil conservation and fertility.

Despite historical integration of indigenous trees into traditional farming patterns, most Kenyan farmers are no longer familiar with the idea of growing herbaceous food or fodder crops in association with trees. Moreover, very little research data is available within Kenya that would make it possible to provide farmers with detailed and precise advice about how to increase the productivity of their land by associating trees with their conventional crops. Relevant data on this subject may be obtained from Rwanda (where very interesting agroforestry and extension work is being carried out), the International Institute for Tropical Agriculture at Ibadan, and elsewhere, including the Nairobi-based International Council for Research in Agroforestry (ICRAF).

Progress in large-scale planting of farm trees will not be achieved until extension agents are in a position to show a farmer living on a slope for example, how if he "sacrifices" 5-15% of his land to tree belts planted along the countour lines or trees between rows of crops, he will not only be spared erosion problems and supplied with wood for fuel and other uses, but the ecological conditions on the remaining 85-95% of the land will be improved to the extent that he will obtain more crops than he previously did from the whole area. This will require both research and demonstration on a broad scale.

In case of semi-arid and arid lowlands, in particular, an improved agroforestry system characterized by scattered and mainly indigenous "farm trees" has a great role to play. Within such systems, the main functions of the tree vegetation will be upkeep of a microclimate favorable to crops, pastures and livestock; protection against wind erosion; nutrient recycling; and fodder production.

The wood-producing function may only be ancillary to the functions directly related to food production. However, if agroforestry systems of this type are applied to large areas, the wood production may be sufficient to cover local requirements. Moreover, in areas such as Machakos District which currently suffer local wood deficits (and where as a result an estimated 65% of the population uses charcoal), local wood production will--if it drives out charcoal use--increase the efficiency of the overall fuelwood production and consumption system.

C. Program Needs

Specific needs to be addressed in this Project include:

- Introduction and testing of numerous species of fast-growing, multi-purpose trees appropriate to Kenya's varied ecological zones;

- Production/acquisition of seeds and cuttings of selected tree varieties already known to be suitable for reforestation purposes within the various ecological zones of Kenya;

- Provision of technical and financial assistance, public [illegible]ation support, and training/curriculum development support to government, and non-governmental organizations whose afforestation approaches and/or past rural extension performance hold promise;

- Demonstration and dissemination of agroforestry approaches appropriate to each Kenyan ecological zone; and

- Provision of information and analytical support to GOK/Beijer effort to develop long-term fuel-wood policies and program.

Species Selection

The selection of tree species for reforestation/fuelwood development is an important technical input to the implementation and success of reforestation/fuelwood development programs in Kenya. Kenya is characterized by a wide range of soils, climates and micro-environmental conditions. Tree species which grow satisfactorily in one area of the country may not perform well elsewhere. Unfortunately, very little research has been undertaken except on a few species suitable for highland conditions.

A list of genera and species recommended for testing is shown in Table A-1. A large number of potential fodder trees and leguminous trees with nitrogen-fixing capacity as well as a few quality timber trees are included.

Table A-1

Illustrative Candidates for Species Research

Species and varieties of the genus Acacia from Africa.
Australia, and South America (e.g. A. nilolica, A. tortilis, A. holosericea, A. plectocarapa, A. praecox).
Ailanthus excelsa
Albizia falcataria, A. lebbeck, A. procera.
Alnus jorullensis, A. rubra
Azadirachta indica
Brachylaena hutchinisii.
Brosimum utile.
Species and varieties of the genus Calliandra.
Cassia siamea, C. sturtii.
Casuarina equisitifolia, C. cunninghamiana
Cedrela odorata, D. serrata.
Cnidosculus sp.
Species and varieties of the genus Euclyptus with special attention to:
E. camaldulensis, E. deanei, E. maculata, E. maideni, E. melliodora, E. microcorys, E. nitens, E. paniculata, E. regnans, E. saligna/grandis, E. viminalis.
Species and varieties of the genus Euphorbia
Erythrina poppigians
Glerecidia sepium
Gmelina arborea
Grevillea robusta
Species and varieties of the genus Leucaena,
Mimusopsis emini.
Ocotea usambarensis.
Olea welwitchii.
Portulacaria afra.
Species and varieties of the genus Prosopis from North and Latin America and from Asis.
Species and varieties fo the genus Pterocarups.
Pygeum africanum.
Sesbania grandiflora
Syzygium cumini.
Vitex keniensis.

This project will establish a network of six demonstration/extension centers in various ecological zones, one of the functions of which would be to conduct species research. At each center roughly 35 species and varieties appropriate to that ecological zone would be tested. In the case of new introductions, the following investigations would be carried out:

- Elimination tests with a small number of plants to determine which species and varieties will adapt sufficiently well to the new environment to show healthy growth.
- A study of growth rate including the various parameters of biomass production.
- Investigation of rooting habits.
- Investigation of shading characteristics.
- A study of the development of rhizobia and nitrogen-fixing capacity.
- A study of the up-take of mineral nutrients.
- Investigation of wood quality with particular emphasis on fuel value and suitability for conversion to charcoal.
- For relevant species, a study of the nutritional value of food and feed produced.
- Investigation of coppicing characteristics.
- Investigation of flowering and seeding characteristics.
- Development of simple, inexpensive planting practices for otherwise promising species with special emphasis on the possibility of direct sowing.

Seed Production/Acquisition

Enough already is known about several suitable plantation species for highland conditions to be confident about seed distribution, e.g. Black Wattle (acacia mearnsii) and several Eucalyptus. Similarly, for certain soil types in the coastal region, Eucalyptus camadulensis, Gmelina arborea, Casuarina equisitifolia, Cassia siamea and neem (Atadirachta indica) are appropriate. Some research and development has been carried out by non-GOK organizations to identify and establish trees on different types of marginal land. Organizations such as Baobab Farm Ltd, The Machakos Integrated Development Program (EEC), IPAL (UNESCO/UNEP), and some church organizations may constitute valuable, albeit limited, sources of germ plasm from which

seed distribution may be organized.

Assistance to Afforestation Groups

Non-governmental organizations with tree planting programs require appropriate seeds, assistance in developing public education materials, and most important, training and technical assistance in nursery development and post-planting maintenance. In addition, limited financial assistance to support an afforestation program manager and/or travel expenses would permit promising national or regional organizations to expand their assistance to local afforestation groups.

Financial assistance will be provided through the Energy Development Fund. In addition. the project will provide:

- At least two forestry/agroforestry experts to provide technical assistance to government and non-governmental organizations, as well as to manage related aspects of the project;

- Development, or support of groups such as ICRAF in the development of, rural afforestation and agroforestry curricula for incorporation at the Forest Department School, University of Nairobi Forestry Department, Agricultural Institutes, Farmer's Training Centers, Adult Literacy training centers, and other appropriate formal and non-formal educational centers capable of reaching extension officers, farmers, or both.

- Newsletters, information documents for educational institutions, posters, films, articles and other material for use by the media.

- The network of six demonstration/extension centers mentioned above will provide seedlings to local organizations, demonstrate techniques of nursery establishment and maintenance, and provide a base for local extension efforts.

Seedlings should be provided at a reasonable price depending on species production costs, which may vary from 20 cents to 10 shillings. Prices would both partially cover seedlings costs and also strengthen users' incentive to provide necessary seedling care during the first few months. This post-planting maintenance is the most critical element in tree planting efforts. Official estimates indicate 70% or more of the trees now distributed for reforestation die shortly after planting for lack of care, partly

because seedlings are distributed at times which are inappropriate for planting, for lack of extension information and assistance, and apparently because of lack of concern for post-planting maintenance.

The demonstration/extension centers also will serve as a seed source in those areas where direct seeding has proved successful. Certain species of Acacia, Leucaena, Eucalyptus and Prosopis are effectively propagated by direct sowing. Where feasible, direct sowing has the advantage of considerable reduction in costs. Post-emergence maintenance is still critical, however.

Nursery and planting technique experiments will include direct sowing experiments (alone and in combination with agricultural crops); preparation, transportation and planting of naked root seedlings; raising of plants in soil blocks; and raising of plants in containers of different materials and sizes. When planting nursery stock in the field, various methods of soil preparation will be experimented with, including the use of subsoiler to bring by hardpan or open up poorly drained and aerated soils.

Agroforestry Demonstration and Extension

Because of the importance of agroforestry and the lack of current organizations focussed on integrated silvicultural/agricultural farming patterns, the project will support a series of demonstrations of the technical and extension/acceptance aspects of agroforestry in each of Kenya's major ecological zones, using the nursery centers as a base. Such demonstrations will include:

- Species trials as discussed above. For tree species to be used in farming systems, the following will be studied: shading characteristics, rooting habits, fodder value of foliage and fruits, mulch value of branches, nitrogen fixation, and uptake of mineral elements.

- Demonstration planting, to include both establishment of conventional forest plantations and planting of trees on land used for cropfarming and pasture, as part of integral multicrop agroforestry systems. Demonstrations outside the centers will include planting of trees along contour lines; plant deep-rooted light-shade trees between rows of maize or other crops; and use species of Acacia, Cactum, Euphorbia, or other appropriate genera for live fences.

- Extension services to farmers, working in close cooperation with field Agricultural Officers. The Agroforestry extension program established in Rwanda with FRG assistance provides one model for how to organize and deliver such extension services and how to combine demonstration and extension effectively.

Information Gathering and Analysis

The Beijer Institute and Ministry of Energy will carry out an eighteen month, $1.4 million Fuelwood Cycle Planning Project commencing in October, 1980. In addition to supporting the Beijer study, this project will use its long-term experts to document and then continually monitor rural afforestation and agroforestry activities throughout Kenya, and to investigate opportunities to promote expanded wood production on underutilized lands. The experts or short-term consultants also will analyze information on Kenyan forest resources and land use generated by the Remote Sensing Centers.

II. Wood/Charcoal Conservation: Improved Cookstoves

A. Introduction

Cookstove improvement potentially offers the most rapid means of beginning to close the gap between fuelwood supply and demand. Over 90% of all Kenyans depend on wood or charcoal for cooking. Most rural women cook over an unenclosed three-stone fire which loses an estimated 90% of the heat value of the wood fuel. "Jikos", metal braziers used by most of the urban poor and a growing number of rural households, similarly are estimated to be delivering only 15% of the heat value of charcoal. At the other end of the cooking spectrum are devices for using "commercial" fuels; kerosene, which for middle-income urban families may be a substitute for charcoal, and gas or electricity, which are affordable only by the wealthy. Between the traditional and the "modern" are numerous devices or methods which potentially could substantially improve upon the efficiency of the three-stone stove or traditional jiko. The project will support development and dissemination of such technologies.

B. Improvements and Three-Stone Stoves

The basic cooker generally consists of three large, carefully selected stones arranged on the ground in a triangle. Fires may be immediately outside the home (as a deterrent to animals), in a sheltered location or, in the great majority of cases, within the home itself. Women generally sit or squat around the fire while cooking over one pot. Within the limitations of the method itself (rated only 5-8% efficient), they are likely to try to manipulate the use of flame, coals embers, and recovered charcoal to try to get as much heat value out of the wood as possible. Rural families also appear to be quite conscious of which indigenous species make the best firewood.

Besides providing heat for cooking, the open fire provides warmth (particularly important in the highlands), light, pest protection, extension of the life of thatch roofs, and a convenient gathering spot. They also have been associated with severe eye and lung problems (due to smoke inhalation) and incidents of small children falling into the fire.

Two primary factors contribute to the low efficiency levels of open fire stoves. First, because air supply cannot be controlled and because desired air-to-fuel ratios vary (depending on moisture content of the wood, wood placement, etc.) air supply may fall below the level required for complete combustion, resulting in carbon monoxide generation and a smoky low-temperature flame which is both inefficient and unhealthy. Second, pots lose large amounts of heat by convection--that is, wind dispenses the heat produced away from the cooking vessel--particularly where the fire is exposed to air currents or breezes.

Among the more promising improvements in three-stone cookers are the following:

1. Enclosure of the fire by a horseshoe-shaped mud wall, or alcove, creating a baffling effect and reducing convective heat losses.

2. Incorporation into new structures or retrofitting in existing structures of air passages for smoke removal.

3. Incorporation of grates for keeping fuelwood above the ground at an optimal distance from the cooking vessel.

4. Division of the cooker into separate elements--glowing coals, active flame, and hot rocks--for variable cooking tasks (boiling, simmering, warming, etc). This is generally arranged sequentially, as one-pot cooking is most prevalent in all parts of Kenya.

In addition, fuelWood saving can be realized without introducing equipment. Substantial efficiency improvement is possible, simply by drying (seasoning) the wood before burning, since moist wood produces less useful heat and more smoke. Also, as mentioned above, manipulation of the fire--especially using the right size pieces of wood and moving them into or away from the center of the stove ring--can have a substantial impact on how much latent wood heat is used rather than lost.

A combination of these ideas can increase the efficiency of cooking well above that of an open fire.Goldenberg at Princeton University tested the efficiency of an open fire configuration with and without use of a simple alcove for convection control. Efficiencies were obtained by weighing the wood before and after burning and measuring the temperature for a given amount of water. The results were 7% efficiency for the open configuration versus 16% with convection control.

C. Other Non-Stove Improvements

1. Fireless cookers in various forms have been traditionally used in many societies for centuries, Their common trait is that they are very well insulated containers. A typical fireless cooker, the Norwegian or haybox cooker, is a closed container insulated with a thick layer of hay,

wood shavings or other insulating material. The opening inside this insulation is just adequate for one or two cooking pots. Once food has been brought up to cooking temperature on a fire, it is covered and placed into the insulated chamber. The cover is then placed on the insulated box and the food inside continues to cook over the next several hours, as its temperature very gradually decreases. The consumption of fuel dramatically decreases when such warmers are used in conjunction with traditional practices.

2. Solar Warmers are devices which use the direct and diffuse rays of the sun to warm up cooked food, increase the temperature of uncooked food before it is placed on the cooking fire, or keep cooked food warm. They consist of insulated boxes with either single or double glazing on the side exposed to the sun. The interior can be either black to absorb radiation and convert it to heat, or reflective to direct the radiation onto the food container. In black interior solar warmers, temperatures often approach boiling after 1 hour of exposure to the sun. The costs are generally low (less than $2 per unit in many countries) and operation and maintenance of the system are not difficult.

In many parts of Kenya weather conditions are favorable for use of solar warmers to supplement existing cooking practices.

3. Incorporation of a smoke release passageway into an existing dwelling. This could be similiar to the construction of a fireplace out of mud bricks or tamped earth. The increased draft can also create a more regulated combustion process.

4. Enclosed pots, etc., can be surrounded with burning embers and leaves in a process somewhat akin to earth charcoal kilns. This process would allow the cook to leave a meal cooking unattended.

D. High Mass Stoves

Improved cookstoves have the potential for significantly increasing (up to 50%) fuel efficiency over open fires. Experience in several countries has shown that the costs of such innovations can be brought within the economic and technical means of the majority of rural people. While it is difficult to generalize, such improved stoves often contain the following features:

- firebox-(or hearth) for containing the fire;
- flue -for directing the flame and fumes of combustion;
- chimney - to provide a draft for air draw and a passage for venting smoke;
- air inlet - to supply oxygen to sustain the flame;
- baffles - to direct the convective heat currents;
- heat exchangers - to transfer heat to the substance to be cooked (this is generally the pot itself); and
- dampers - to control the flowing air or draft.

Improved stoves can be made in a variety of designs using many different types of materials. Mud, dried bricks, sun-dried clay bricks, clay/sand mixtures, dung, agricultural residue, and sheet metal have all been used to make improved cookstoves. Choise of materials is generally a function of what is locally available, the costs involved, and what the builders and users are familiar with. Many of the designs evolved over the last 25 years have used primarily earth--simply because it is the cheapest and most maleable material.

Earthen stoves are uncommon in most parts of Kenya, although indigenous brick stoves are scattered in the Kakemega-Eldoret area of Western province and it is possible that other isolated examples exist throughout the country. Recently, however, organizations including UNICEF's Karen Village Technology Unit, the Home Economics Department of the Ministry of Agriculture, and the YWCA-- have begun experimenting with high-mass stoves which families can build themselves using inexpensive, locally available materials (earth, dung, scrap metal, etc) as a means of conserving fuelwood.

The UNICEF Karen Village Technology Unit (VTU), which receives several thousand visitors annually, has displayed several improved cooking appliances including enclosed woodstoves, improved jikos, hot-box cookers, and various solar cookers, which have had only limited impact outside the VTU's thus far. Until last year, Karen Center had demonstrated the raised outdoor cooking platform and a replica of an experimental stove from Western Province called the Kakamega stove, both of which use earthen (Cinva Ram) bricks and cement mortar topping. The raised cooking platform stove contains a medium-sized firebox with a curving flue, enclosed water heater container and small chimney. Both stoves are outdoor stoves, a problem since most women cook indoors. These stoves have been updated at Karen by the "Karai stove" (Figure A-1) developed by Mama Elisabeth Manjiko independently after she had heard of the earthen stove experiments at Karen. The stove is a large platform constructed of earth, with sticks and stones as reinforcing members. Two burners are located above a large carved firebox (combustion chamber), which contains a heavy metal grate about 8-12" below the burner holes. The stove also incorporates a straight flue and upright chimney with optional enclosed water jacket. A large wooden door is fitted on the front of the stove once the fire is lit to act as a form of damper.

According to tests performed by the Intermediate Technology Development Group, the Karai stove exhibited the following characteristics; (1) It gives acceptable performance for long cooking times. Efficient combustion and heating of the stove walls(thermal mass) to steady state takes 40 minutes. Until that time the stove does not perform well. (2) Not shutting the wood door would significantly decrease the stove's efficiency. (3) The chimney height (3") is about optimum and the burning rate is close to optimum for mud stoves. (4) Additional minor improvements without significantly altering the design are possible, such as changing the shape of the flue and combustion chamber and placing rods in the chimney for increased heat transfer to the water jacket.

Figure A-1 . Frontal view of the Karai Stove developed by Mama Elisabeth Manjiko as built at Karen Village Technology Center. Contains two burners and 1 water heater attached to chimney. Construction materials - earth, stones, wood scrap metal, sheet metal.

With the support of the Karen VTU and NORAD, women in the Karai area (a relatively prosperous area near Nairobi), have built over 15 demonstration stoves. Orders have reportedly been placed with Mama Elisabeth and her women's group for 50 more stoves at 300 shillings (US$42) each. The costs of construction materials are but a small fraction of this figure.

Mama Elisabeth has also conducted a stove-building workshop for Peace Corps-Volunteers in Lugari, in Western Province. Those present expressed some concern over the rather rigid insistence by the designer on faithfully copying her model which requires an unfamiliar standing posture. Additionally, soil tests or material controls appear not to have been used during the construction phase, which could lead to stoves crumbling or otherwise deteriorating soon after being built.

Although less publicized, several district and divisional level Home Economics officers from the Ministry of Agriculture have begun to teach women's groups to build earthen stoves. Stove building is often one of the many components of Home Economics training given at Agricultural Institutes and at the Egerton College. In addition, some officers have visited the Karen VTU.

These stoves reportedly vary in size and shape. Common denominators are relatively low(45cm) height, makeshift chimneys for smoke clearance, and poor to moderate resistance to cracking. The women accommodate this problem by mud and dung patching at regular intervals (in one case, once a week)

In general, it appears that most of these Home Economics officers have not received sufficient training in stove design parameters, the need for soil tests, and how to conduct such tests, and other important aspects of stove-building. Soil testing is particularly critical, since characteristics of soils even a few meters apart may vary widely. If mixtures are not adjusted to accommodate varying soil characteristics, earthen stoves may crumble or crack literally hours after completion of construction.

Talbe A-2 summarizes some recent experience with high-mass stoves throughout the world. Fuel savings shown should be interperted, cautiously, since rated efficiencies are quite sensitive to assumed cooking methods, details of the test methodology, etc. In addition, the cookstove program in Senegal is providing valuable experience in both stove design parameters and extension techniques.

Stove designs should be not only energy conserving but responsive to specific local needs and cooking methods. The following are minimal design standards for"improved"stoves.

- The cost must be low in actual cash outlay and time expenditure;
- The stove must be durable enough to withstand heavy use without cracking for at least a year and preferably longer.
- The designs should be able to be constructed with locally available handtools, from local materials such as mud, crop residues, sand, dung etc., which can be made into bricks or molded.

Table A-2

Design features of Improved Cookstove Designs

Design	Design features: major materials requirements	construction tools	local skills	fuel	Performance estimates	Cost estimates	Reference and date
High-Mass Stoves							
IIRR chula	moist earth; cow dung; fired-clay attachments; tin	yard measure, spatula, knife, string, trowel, tin template	local skills; potter	wood, charcoal, or coal	20 to 40% fuel savings[a]	--[b]	14 (1953)
Egyptian stove	mud; mud bricks; fired-clay plates; drainage pipe	--[b]	local skills; potter	corn or cotton stalks	16 to 70% fuel savings[a]	0.15 ✗ E	20 (1953)
Bagan chula	prepared clay; straw or fiber; cow dung; iron rings and plates; fired-clay pipes	wooden rod	local skills; potter; blacksmith	wood, charcoal, and other combustible materials	33% fuel savings[a]	2 to 3 Rs	18 (1955)
Singer stove	clay; sawdust, rice husks or ashes; fired-clay bricks and plates	wood forming blocks	local skills; potter	wood	27 to 29%[c]	--[b]	17 (1961)
Hasimu stove	concrete; metal plates; oil drums	concrete molds, metal cutters	local skills	wood	--[b]	~ $30	15 (1978)
Ghanian stove	clay or laterite; sheet metal; steel rods	--[b]	local skills	wood or charcoal	--[b]	--[b]	22 (1976)
Lorena stove	sand and clay; sheet metal	shovel, spoon, sifting screen, machete	local skills	wood, charcoal, or other combustible materials	50% fuel savings[a]	$15 to $35	23 (1977)
Low-Mass Stoves							
Indonesian stove	fired clay or ceramic materials; iron grate	--[b]	local skills; potter	charcoal	27 to 36%[c]	--[b]	17 (1961)
Kenyan cooker	ceramic materials; metal grill	--[b]	local skills; potter	wood or charcoal	--[b]	--[b]	28 (1978)
Honduras stove	metal paint can; broomstick; metal pipe	welding, metal cutters	metalworking	sawdust	--[b]	--[b]	29 (1977)
Philippine stove	concrete; metal pipe; wooden funnel; metal grate	concrete molds, metal cutters	metalworking; potter	rice husks	--[b]	$80 to $135	32 (1978)

[a]These values refer to fuel savings compared to traditional cooking practices.

[b]No entry indicates that no information is reported in the literature.

[c]These values refer to percentage of the heating value of the fuel used for cooking.

Source: Center for Development Technology, Washington University, St. Louis, MO, Appropriate Technology for Renewable Resource Utilization, 1979, USAID Contract No. AID/USAN-C-0061

- The stove should be simple to operate and understand, should utilize the types of fuel available, should accommodate existing cooking methods, and should allow for local innovation and adaptation to preferred cooking methods.

E. Low-Mass Charcoal or Wood Stoves

Low mass charcoal burners have been a part of Kenya's culture since the beginning of the 20th century. The metal braziers commonly called "jikos" are thought to have been introduced by Arab traders or Indians who came to build the Kenya-Uganda Railway. Over a period of 70 years, a relatively standardized series of designs has evolved encompassing various sizes and degrees of durability.

Jikos are made of scrap metal about 1mm. thick and include small pieces of steel reinforcing rods for pot supports. The most typical household model is cylindrical in shape and consists of three components: the metal shell, a fire grate with opening (representing roughly 10% of the base area); and appendages (base supports.)

Jikos are built almost entirely by informal sector artisans who acquired their skills outside of formal education channels. In addition, some Village Polytechnics* are beginning to offer courses in jiko making. Raw materials for jiko manufacture are purchased from informal sector scrap metal dealers, who obtain their scrap metal from garages and factories in urban areas.

Unfortunately, 85% of the energy value of charcoal cannot be used for cooking purposes due to the thermal inefficiency of the jiko. Most of the heat value of the charcoal is lost through the metal walls by radiation or through seepage around the cooking vessel by convection. On the other hand, in highland areas, this heat loss from cooking is useful during colder times of the year for space heating.

In early 1980, a major publicity campaign was generated in Nairobi to promote a new improved jiko developed by Waclaw Micuta of the Geneva-based Bellerive Foundation for Primary and Renewable Energies, which was claimed to be two or three times as efficient as the traditional one. The NCST and the Ministry of Energy sponsored a demonstration of the improved jikos and initiated a six-month study of their social acceptability and economic viability.

The Micuta Jiko (Figure A-2) is cylindrical in shape, as is the traditional jiko, but is made of heavier plate steel. It is built of double walls to reduce heat loss by radiation, and one model is fitted with a chimney and damper. A funnel placed on the grate located 6" from the floor diverts heat to the central point of the cooking vessel. A pan with an attached bellows allows for the lighting of charcoal with kerosene and paper. This jiko, rated in Switzerland at an efficiency of 30%, is priced at Ksh 350 (US $45), versus a price of Ksh 25-50 for traditional jikos.

* (Two-year technical training centers)

In testing by selected consumers, generally higher efficiencies were reported, but dissatisfaction with the design arose. The new jiko was considered to be too expensive, too heavy, and bulky (making it difficult to carry outside, where jikos conventionally are lit), too slow to start up (particularly for boiling water for morning coffee or tea, and lacking bottom supports. Also, jiko makers found the Micuta jiko expensive and time-consuming to fabricate.

The NCST and Ministry of Energy then commissioned informal sector jiko manufactures to build and distribute modified versions of the Micuta jiko which incorporated recommendations by the testers. These modifications revived many of the features of the traditional jiko, i.e., three leg supports, an air inlet without bellows, and scrap metal construction. (Figure A-3)

Costs decreased in Ksh 120 for a 12" diameter jiko and Ksh 30 for a 9" diameter model. In a further modification, the vertical portion of the chimney was eliminated and the price for a 12" model decreased to Ksh 30.

Preliminary tests at Kenyatta University College and the University of Nairobi, on several of jiko designs so far have been inconclusive and have been stalled recently due to funding restrictions.

An additional jiko development project has proceeded largely unnoticed under the auspices of the National Christian Council of Kenya's (NCCK) St. John's Community Center. The NCCK operates a small program providing scrap metal and other raw material in bulk at cost to informal sector producers. A collaborative effort between the jiko makers and an NCCK volunteer produced a metal shell jiko with a soil cement insulating lining, an air chamber for preheating and a small ring of metal to support smaller pots This is the only known example of a metal low mass burner incorporating soil insulation. Tests at Kenyatta University College give this jiko a rating equal to other improved jikos.

Egerton College, at Njoro, has been experimenting with multipurpose jikos including baking oven combinations, commercial kitchen designs, and water heaters, some of which are available on the market.

National Council for Science and Technology (NCST) sponsored a workshop on July 24, 1980, which included representatives of the Ministries of Energy, Environment and Natural Resources, Commerce, and Industry and the NCCK, Kenyatta University College, University of Nairobi, UNICEF/Karen Village Technology Center and the USAID Renewable Energy Development Project Design Team. The following recommendations were made:

1. Further research and development efforts should be carried out to further improve the performance of the improved jikos.

2. Public institutions and non-governmental institutions should be donated to improve jikos for more conclusive testing results.

3. Improved jiko designs should be promoted at village polytechnics and regional agricultural exhibitions.

Two prototypes of Micuta's new jikos flank the currently used charcoal jiko.

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Figure A- 2 . Two prototypes of Micuta's new jiko flank the currently used jiko.

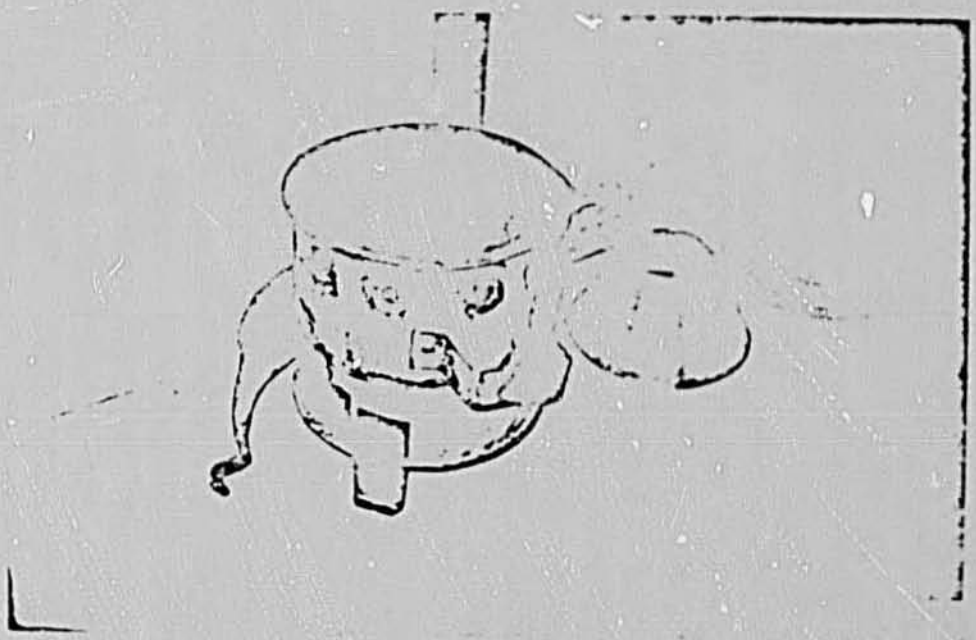


Figure A-3 The NCST Adaption with its separate components. From left: 1) Main body of burner; 2) conical heat transfer materials; 3) burner plate for cooking vessels

4. The production of jikos should be stimulated in various parts of Kenya.

5. Jiko improvement programs should be complemented by programs to improve the efficiency of charcoal production.

6. Alternative fuels to charcoal (agricultural residues) should be more fully utilized.

7. A program to develop efficient wood stoves is highly recommended.

8. The overall improved wood and charcoal technologies effort should be a national one supplemented by "international interactions".

9. A special coordinating sub-committee comprised of the organizations represented at the meeting should be constituted to give continued guidance and support to the efforts completed to date in improved jikos and energy-conserving technologies.

As in the case of high-mass stoves, there may also be an opportunity to take advantage of experience gained elsewhere. In particular, preliminary tests at the University of Dar Es Salaam by, Keith Openshaw indicate that a typical inexpensive ($2-$3) stove used in Asia is about twice as efficient as the jiko! This stove consists of on outer layer made from tin sheets, a middle layer of ash/clay filling, and a fired clay inner liner (Figure A-4). Similarly, inexpensive metal wood-burning stoves have long been used in Addis Ababa. Such stoves both are more efficient than three stone-stoves and potentially represent a device for introducing wood-burning cooking into urban areas where wood is located within an economic transport distance. Table A- summarizes other low-mass designs.

F. Other Lower-Priority Technologies

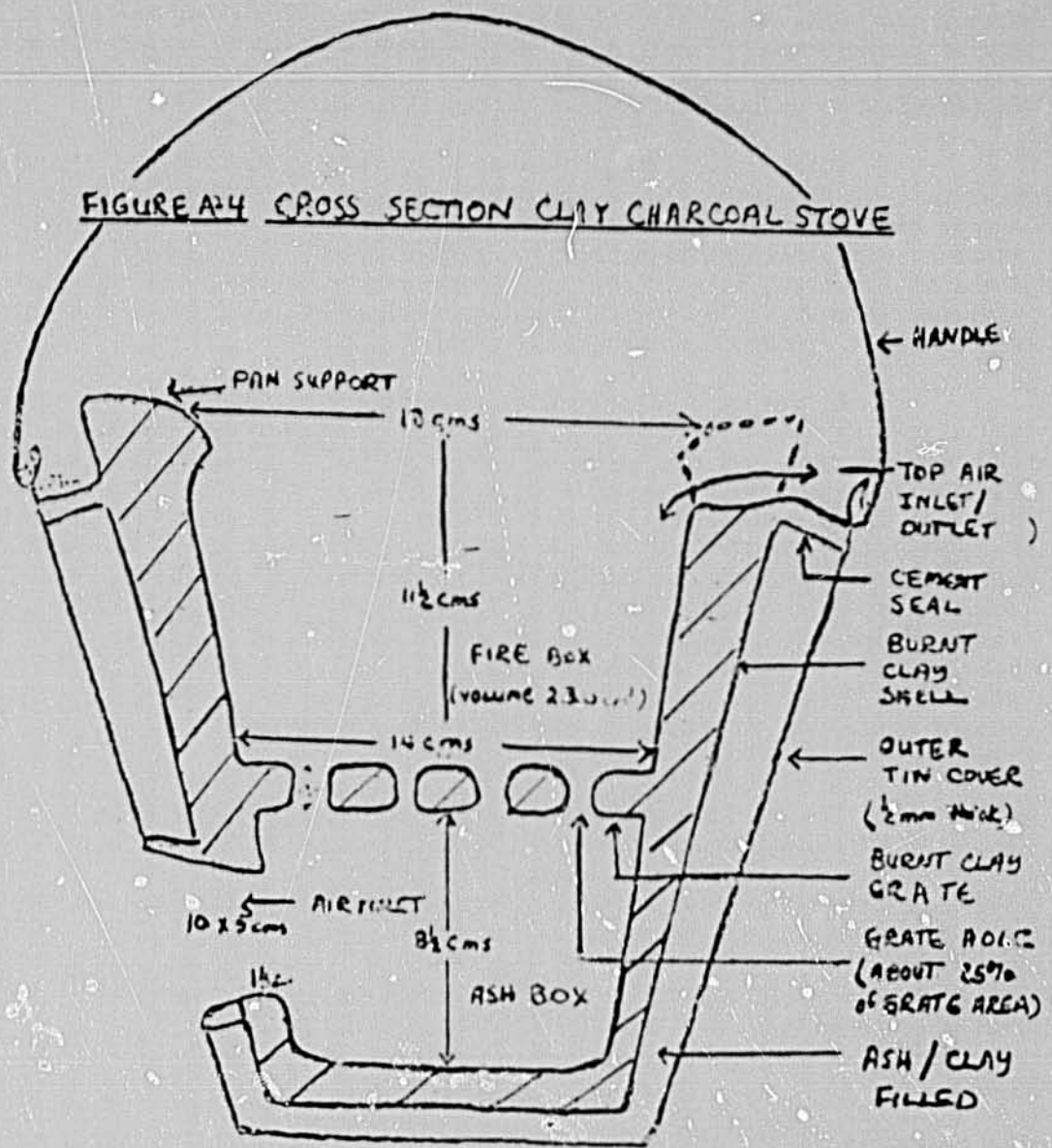
Various other cooking technologies are considered to offer less potential and these are accorded a lower priority.

1. Agricultural Residue Burners generally are either one-burner low-mass models using a compressed or pelletized fuel or high-mass natural draft stoves with grates upon which the fuel is suspended.

The small agricultural residue stoves being experimented with in Kenya, as well as those of similiar design used in Asia, are essentially like jikos constructed of waste paint cans or small drums. This design creates a flue effect within the container, creating a constant flow of oxygen next to the outer surface of the compressed agricultural residue. The designs at the Egerton College Home Economics Department are an improvement on this design in that they incorporate a funnel in place of the more traditional horizontal passage, which is generally less structurally sound and prone to collapse.

1) Keith Openshaw, "Energy Requirements for Household Cooking in Africa With Existing and Improved Cooking Stoves", University of Dar Es Salaam, April 1980.

Figure A-4



Soruce: Keith Openshaw,
A Compariaon of Metal and Clay Charcoal Cooking Stoves,
University of Nar es Salaam, Morojaro

High-mass versions of agricultural residue burners can be constructed of earth, fired bricks, and cement. Varieties of such designs exist throughout Asia, but are generally used not for cooking but for energy production in food processing industries such as coconut, sugar extraction, and soymilk manufacture. For Kenya, such burner designs also are more likely to be relevent to industrial than to household cooking needs.

Most agricultural residues with high energy content already are used for purposes other than domestic cooking. Typical uses include on-site energy production at the agricultural processing plant generating such residue, use as animal feed, or use as fertilizer. The amounts used for domestic cooking, while in some cases regionally significant, are very low compared to wood or charcoal. Existing designs at Egerton College and elsewhere appear adequate to support existing cooking use.

2. Biogas for Cooking; Kenya has experience in biogas generation spanning a period of over thirty years. Mr. J. Hutchinson of Runnel Estate Ltd. has operated and manufactured plants on his farm at Fort Ternan since 1948. The sewage works at Kariobangi and Nakuru are anaerobic systems which burn'off large quantities of excess biogas daily. However, the experience for individual farmers who have attempted this technology have not been widespread or particularly satisfactory. Hutchinson's 15-cow plant produces enough gas for cooking for three adults per day. Both the number of animals required and gas production fall far short of addressing the needs of most rural people in Kenya, and the actual installation costs for Hutchinson's plants and projected construction costs for Chinese-type fixed dome biogas plants exceed the investment capacities of all but relatively prosperous landowners.

The high capital requirements for biogas systems--including not only the biogas unit itself but the confined animals necessary to feed the unit--put such systems well beyond the reach of the rural poor. Biogas is appropriately considered as an integrated system providing energy, production, waste management, and other benefits. Energy for cooking is likely to constitute only a minor share of such benefits, and then only for agricultural colleges, dairy farms, or other cases combining both a large number of confined animals and groups/institutional cooking and dining.

3. Solar Stoves experience in Africa and elsewhere suggests that is is extremely difficult to introduce solar stoves. In Kenya, cooking generally is done inside, and most cooking is done at night and in the early morning. Solar stoves which require outdoor cooking during the middle of the day, thus do not appear to be a promising technology for general use in Kenya.

G. Project Needs

Expert Assistance and Training

A primary need is for experts to train home economics officers, community development officers, Peace Corps volunteers, women's organizations

and others in the techniques of local design , adaptation, and construction of owner-built stoves. It currently appears that extension workers' enthusiasm often is not matched by their knowledge of the subject.

Experience in Kenya and elsewhere suggests user acceptance rather than lack of technology has been the major problem . The experts provided therefore are to be at least as strong in rural extension as they are in the technical aspects of soil mixtures, thermodynamics, etc. The AID "Improved Cookstoves for Rural Senegal" project--which emphasizes creation of a supportive environment in which rural villagers identify their cooking needs and with the "experts" limited largely to providing technical alternatives and considerations, design their own stoves--provides a model for extension of owner-built stove technologies. This extension approach is at least as important to impact as the technical information itself.

In addition to a long-term cookstove extension expert, it would be desirable to use groups such as the Aprovecho Institute (which undertook the Senegal project), ITDG, or others as short-term consultants to design and/or participate in extension training programs. The Karen VTC and training facility would appear to be well suited as a site for some training of extension officers, in addition to incorporation into curricula of Egerton, the agricultural institutes at Embu and Bukura, the Coast Training Institute, KIA, Farmers' Training Centers, and other training institutions. In addition, as in Senegal, at least some of the training should include cooperative field extension projects to generate participatory cookstove design and construction in rural villages.

Survey and Assessment

The long-term expert should promptly initiate an informal survey and assessment of cooking methods and cookstove innovation in Kenya and of promising cookstove development and extension approaches being pursued elsewhere in Africa. Also, in conjunction with the forestry expert and a short-term sociologist, he/she should undertake an assessment of the potential for introducing wood for cooking into urban areas. This assessment would address the availability and likely procuring of firewood, availability and cost of wood-burning stoves, and issues of social acceptability.

Design and Testing of Commercial Stoves

Particularly for improved jikos but also for portable clay stoves or metal wood-burning stoves, the project should support innovative design and testing of stoves which can be manufactured commercially. Options for providing such support (through the Energy Development Fund) include placing orders directly with jiko and/or pottery makers, contracting with Village Polytechnics, support of the NCCK jiko program, and providing grants to or contracting with one of the AID Small Enterprise Development Program contractors(Partnership for Productivity or Technoserve) to stimulate

commercial manufacture of improved jiko or other stoves.

Stove Testing

The project should use the Energy Development Fund to support a moderate stove testing program for both high-mass and low-mass stoves. The Design Team recommends the following ptions for carrying out such testing.

- High-mass stoves: Egerton College or Karen/ITDG

- Low-mass stoves: Existing NCST testing program.

Financial Support for Extension and Demonstration

A high priority of the Energy Development Fund should be to provide some financial assistance to promising cookstove extension organizations already operating in Kenya. Such support should include in-country travel expenses, construction materials, preparation of educational materials, and in selected cases partial funding of a cookstove project director. In the cases of Village Polytechnics support could take the form of contracts for completed jikes. Also, the project would, under the "Expert Assistance and Training", component above, provide training of and technical assistance to these groups' staffs. The Design Team recommends the following organizations for possible support:

- High-mass stoves: Peace Corps, NCCK, Karen/ITDG, possibly YWCA.

- Low-mass stoves: Village Polytechnics, NCCK, possibly Partnership for Productivity.

III. CHARCOAL PRODUCTION SYSTEMS

A. Introduction

Charcoal is produced by burning wood and other carbonaceous materials under conditions that severely limit the amount of oxygen available for combustion. High temperature heating by various methods break down the original substance into gases, a watery tar mixture, and the familiar solid carbon material known as charcoal.

Compared to wood, charcoal has a number of advantages: high-heat value per cubic meter compared to wood; low ash content; smokelessness; flavor imparted to food; ease of storage; and the simplicity of charcoal stoves, which make possible the use of the fuel with very little cash outflow. However, particularly with traditional conversion processes, 30-50% or more of the latent heat value of the wood is lost in producing charcoal.

There is great scope for improving yields over the current inefficient earthen or pit kilns used throughout Kenya. Options include inexpensive modifications to existing processes, portable metal kilns, and stationary brick or clay kilns. There also are important issues relating to the desired scale of the charcoal production--which currently consists primarily of thousands of small-scale intermittent producers--and whether producers should bear any responsibility for forest management and conservation of forest resources. Until such time as broader GOK policy decisions regarding such issues is reached, the project should concentrate on improving traditional charcoal production methods.

B. Improvement in Traditional Earth Kilns

The simplest way of making charcoal and the principal method used in Kenya, is in earth kilns. Traditional earth kilns are generally one-or two-person operations. Basic hand tools, shovels, hoes, (Jembes), machetes (Pangas), axes, and perhaps rakes may be used in the cutting and stacking of wood and in the digging, covering, and charcoal recovery operations. For larger trees, an occasional chainsaw may be rented, or various hand saws (bow-saws, 2-man cross-saw, etc.) may be borrowed or acquired. The chief advantage of both is that almost no capital is required as the kilns are constructed entirely from locally obtainable raw materials. The main disadvantages are that yields are extremely low (8-10% by weight, and possibly lower, depending upon the skill and experience of the producers).

Two variations of traditional earth kilns are particularly prevalent in Kenya:--charcoal stack kilns and earth or pit kilns. The charcoal stack is a relatively original process used mainly in Kenya. The earth and pit kiln are of the same type used in other African countries.

In the charcoal stack method, stout poles are laid out in an almost triangular shape, generally 5-9 inches long and 0.5-3.4 inches wide, with dry sticks packed in between the poles. The stack is covered with green grass (3-5 cm. thick). The final cover of the stack is a medium layer (10-25 cm. thick) of damp soil which is spread all over to pack it down firmly and to fill up any possible interstices. There are square apertures of 20 cm. by 20 cm. left at the bottom of the apex end which are used to admit the fire when being started, and there are 4-5 small more evenly spaced square vents (12 cm. by 12 cm. each) at the top of the rear (posterior) end.

The fire is lit through the main aperture at the bottom of the apex end. This main aperture is gradually reduced in size as the fire continues, and eventually blocked completely after about 2-3 hours and after the fires has covered approximately a sixth of the stack. Depending on the size of the stack. the fire usually takes up to two days to reach the rear end of the stack once lit. During the normal burning for the first 12 hours the vent holes at the top rear end of the stack are left open. Three to four new vents (about 10 cm. square) are made on the floor level at the rear end, and these enable the fire to continue burning after all the other vents have been closed. It is important that the stack is continually watched as it burns, and to close immediately any cracks releasing smoke and flame.

In the normal burning procedure, the smoke will cease after 3-6 days, and once this is noticed the stack is allowed to cool for another 2-4 days before being opened. After these periods, the stack is then opened again beginning from the apex end. Since charcoal is still hot at this stage, it is spread out to cool by using a shovel or similar tool. Well burnt charcoal is later separated from half-burned wood, the former being packed in sacks and transported to consumers while the latter is placed into the next stack to be burned.

The other method--earth or pit kilns-- encompasses numerous variations of stacking and covering the wood to be burned, above ground or in dug pits. Wood generally is less carefully organized than it is above, the successive layers of covering less elaborate, and the general process more rudimentary. However, the basic technique--stacking the wood above or below ground, covering it with layers of grass, and then covering the whole with an insulating layer of damp soil--is similar.

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1) Parts of this section draws heavily on Prof. J.O. Kokwaro's paper, "Indigenous and Introduced Common Firewood Plants of Kenya"

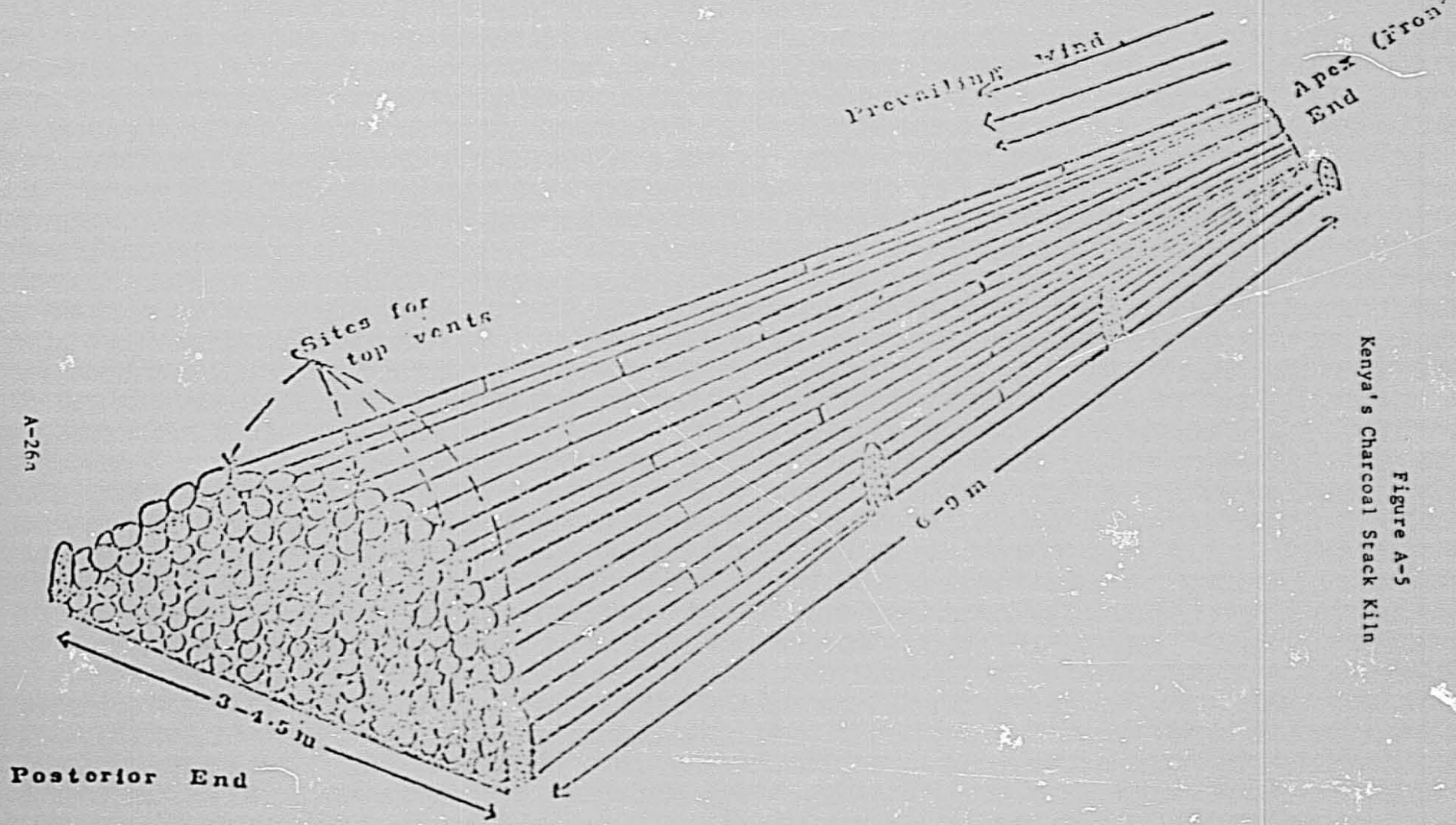

Figure A-5
Kenya's Charcoal Stack Kiln

Although charcoal stack method provides superior yields, a vast majority of charcoal producers have adopted more rudimentary earthen kiln methods due to unavailability of wooden poles and the reduced weight and work requirements involved.

The outputs, scale and frequency of two earth and pit kiln charcoal producers encountered by the project design team is described for illustrative purposes. Producer A is an unlicensed intermittent charcoal burner in a low potential area in Lower Embu. His earthen kiln is inadequately covered with earth, and he receives a return of approximately 10 sacks (at an average of 34 kg/sack) from his 9-cubic meter kiln. Assuming 700 kg/m ^{3} as the weight of the wood and that 70% of the space of the kiln is taken up by wood (the remainder is dirt and pockets of trapped air) this process has a conversion yield of about 6% by weight, compared to the estimated national average of 8.33% (12 tons of wood to produce 1 ton of charcoal). This individual may spend up to 2 weeks in the total operation of gathering the wood, operating the kiln, and waiting for trucks to transport his product. However, the roughly Ksh. 150 (US$21) is a welcome income supplement.

Producer B is licensed by the Forest Department office in Meru District to extract wood for charcoal production from both gazetted forest and communal trust lands. He uses a bicycle to carry charcoal sacks to town in order to obtain better prices(Khs. 24 delivered price versus Ksh. 15 when purchased by lorries). At a reported production of 200-300 bags a month and 15 bags per firing, he produces charcoal quite regularly. His operations represent four days of preparatory labor (three days to cut and pile the wood and one day to build the soil/grass insulation mound), and vigilant maintenance throughout. This producer has 3-4 kilns in various stages of production and appears to achieve 8-10% charcoal yield by weight.

This operator apparently is unrestricted by authorities within his one square kilometer operational territory. Occasionally, rental of a chainsaw (priced at KSh.60 for a liter of petrol and the corresponding services of the saw operator) is required. Actual wood costs are KSh. 18 75 cents for cubic meters of stock and occasional "service fees".

Most charcoal producers appear to fall somewhere within the spectrum represented by these two individuals. Extension services and research and development efforts in Kenya have shown limited interest in increasing the efficiency of these traditional charcoal producers.

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1) Project design team members are skeptical about this producer's reported output figures, since they seem quite high.

The efficiency of these traditional operations can be significantly improved if the following measures are taken by the producers. The costs involved are minimal or negligible, and the results appear to promise up to 50% or greater recovery in weight of the charcoal produced.

(a) Basic Kiln Improvements Requiring No Investments

- The wood used should be seasoned (dried) as much as possible. This helps to assure a higher quality more durable product.
- The wood should be separated into relatively uniform pieces. This helps to avoid small pieces being converted to ash or fines and larger pieces undergoing incomplete combustion. If mixed sizes are harvested, they should be segregated into more than one kiln.
- The wood should be packed as tightly as possible. This also contributes to a uniform, more regulated firing.
- The earth covering the kiln should be sufficiently thick to permit complete combustion t least 6" and up to 12" is recommended (or over an extended hand's length). To ensure that the required thickness is maintained, the kiln should be examined frequently throughout the carbonization cooling cycle. This will necessitate an occasional visit during the night.

(b) Basic Tool/Material Improvements Requiring Minimal Investments

- To facilitate more uniform cutting of the wood pieces, larger axes with wedges, which can be made of hardwood or scrap should be employed. The cost could involve Ksh. 30-50 (US $4-7) or the selling price of 2-3 34 kg. bags of charcoal.
- Instead of relying almost exclusively on the machete(panga) when harvesting smaller limbs and branches, a tempered curved pruning saw (cost approximately Ksh.26, or US$4) could be used. Since the imported Chinese and German spring steel models last 3-10 times longer than those produced in Kenya and only cost 50% more, it would seem prudent to obtain them instead. A moderately good panga costs about Ksh.18, (US$2.50) and is quite proficiently wielded by the producers. However, in the process, trees which are not completely cut down are often severely damaged. Thus the regenerative potential of the tree and future yields are significantly reduced. A further tool refinement here, if not already in use, would be the purchase of improved pruning 24-30" bow-saws for intermediate sized wood. (These cost Ksh.45-60 in most parts of Kenya).
- A minimal-cost but maximum-impact innovation involves the insertion of sheet metal between the mounded wood and the insulation earth layer. This can be simply accomplished by purchasing the 1½x1x1 foot tin canisters called "debes" (cost approximately Khs.1½ to2) and flattening them out to obtain a 1½ x 4" sheet. 12-24

debes can accomplish the task of preventing mixing of soil with charcoal and be reused several times. Alternately, corrugated or flat sheets, whose durability exceeds that of the debes, may be utilized. The debes or sheet metal should be loosely overlapped to allow for smoke and water vapor escape. Figure A-6 illustrates this concept.

Figure A-7 depicts a partially improved traditional earth kiln, located at the Embu Town Lumber Cooperative. Here, scrapwood from the sawmill operation is piled and covered by the corrugated iron sheets on the top and sides as shown. However, the wood pieces are disaggregately sized, largely softwoods; and the insulating soil layer does not enclose the entire kiln. Apparently, this operation produces charcoal only for the worker's own consumption, and waste wood is rather plentiful, so incentives to improve the kilns illustrated here are slight.

C. More Substantial Alterations to Traditional Earth Kilns

FAO-UNDP charcoal projects in other parts of Africa, particularly Senegal, have promptly improved methods of production which differ greatly in technique but only slightly in cost from the methods currently used in Kenya. These projects found that (1) yields from traditional kilns have been greatly underrated and (2) new methods that give yields of up to 30 percent by weight can be achieved if done correctly with dry wood.

A prototype improved traditional kiln, described by G.E. Kasdi, and USAID's Senegal Renewable Energy Development Project, is known as the "Casamance Kiln".

Instead of building the stack directly on the ground, an air space is built underneath by means of a network of logs. A circumferential air chamber is also created by laying an apron of brush on the outside and a chimney is placed beside the stack. The air spaces and chimney result in better combustion of the volatile gases and/or less heat loss from the stack. The chimney (purchased and/or fabrication) costs reportedly can be recovered the first time it is used.

Other advantages of the "Casamance Kiln" include an ability to mix wood size, density and moisture content without adverse effect. The Casamance kiln has demonstrated that smaller or less dense logs will stop burning when carbonization is complete(i.e. they will not turn to ash) even though logs next to them are still burning. Finally, tests of the kiln in comparison with traditional kilns reveal that the former takes 0.5 to 0.7 hours to carbonize one stere(stacked cubic meter) of wood whereas the latter takes 3.6 to 7 hours. This is a significant saving for the charocal makers.

The introduction of air circulation passages and chimneys into earth kilns is a practice in use in other parts of the world as well, including the South-eastern United States, South America and Southeast Asia. The applicability of such methods in Kenya should be examined as part of the project.

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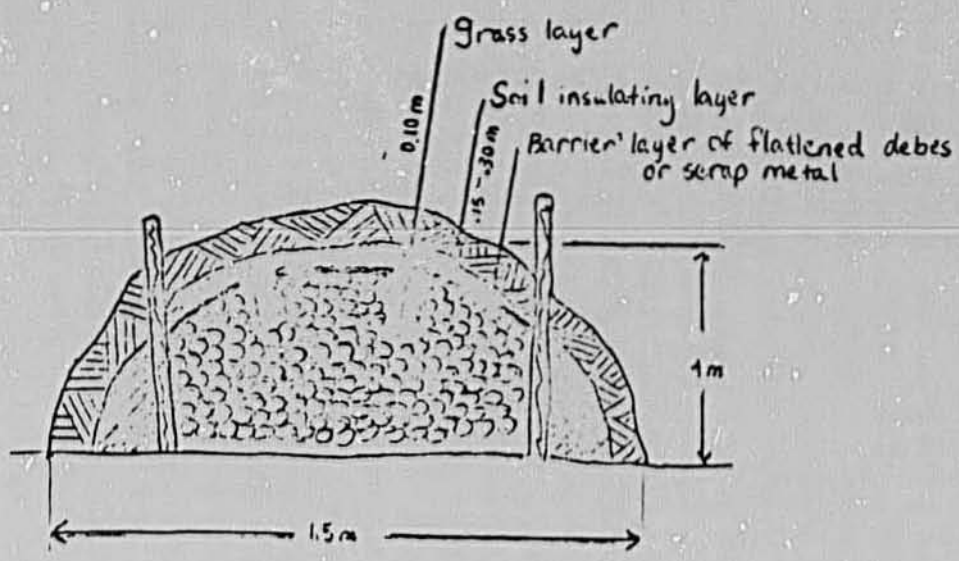

Figure A-6 Low cost Improved Traditional Earth Kiln

Figure A-7 Minimally-Improved Traditional Earth Kiln located at sawmill cooperative, Embu Town, (a licensed operation utilizing scrapwood for workers' own consumption)

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D. Technologies Dependent Upon GOK Charcoal Production Policy

(1) Portable Metal Kilns

Significant original research and development in Kenya and Uganda has led to prototype development and continuous manufacture of portable steel kilns. Burns and Blane Ltd., a steel equipment fabrication company headquartered in Nairobi, has been producing portable steel kilns to order since 1969. Their CUSAB (Charcoal from Unwanted Scrub and Brush) kiln has not been manufactured since 1972 after the designer left Kenya, but they continue to receive orders for their Mark V kiln (Figure A-8). Currently, only 3 to 4 Mark V kilns are produced per year. These are sold primarily to the Forest Department for demonstration purposes and to large agricultural and forest products industries in the central highlands, such as the Del Monte Pineapple plantation in Thika. The current price of the prefabricated kiln is K sh. 23,500 plus tax (over US $3,200). The company provides repair and maintenance services to its customers. In addition, the Tropical Products Institute (Londani) has designed an improved version of the Mark V kiln.

The Mark V or TPL kilns have substantially higher yield than do traditional earth kilns (10-15% vs. 8-10%), still could be considered small-scale (50-55 tons per annum vs. 30-45 for a producer operating three earth kilns simultaneously), and are moderately portable. On the other hand, their high initial cost and the need to transport them by Land Rover or lorry put them outside the reach of most small businessmen and virtually all traditional charcoal producers. As discussed in the Economic Analysis, portable steel kilns are likley to be adopted on a broader scale only if the GOK adopts policies to make charcoal producers responsible for maintaining forest resources.

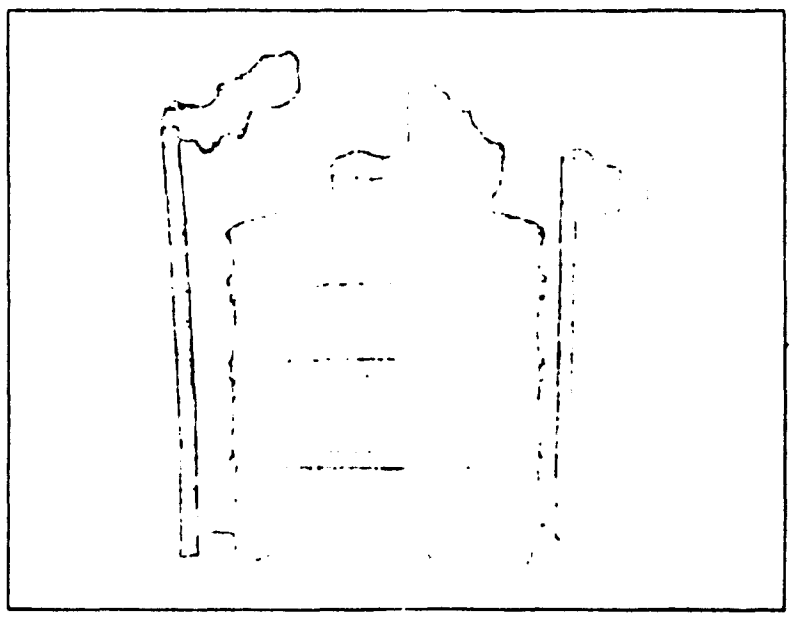
(2) Fixed Kiln Systems

Large-scale fixed kilns and retorts utilizing sophisticated machinery and operational controls are most commonly used in industrial charcoal operations associated with sustained yield plantations. The largest industrial charcoal production operation in Kenya (and most of sub-saharan Africa) is located on EATEC's 50,000 hectare black wattle plantation near Eldoret. Twenty-eight massive fired brick kilns (Figure A-9) convert average 60-ton loads of stacked debarked black wattle from the company's tanning operation into 15 tons of high-grade charcoal--a 25% yield of the oven-dried weight of wood. The scale of the operation is immense: 120 workers are employed in the charcoal enterprise alone.

Fixed-kiln systems also are available for small-scale operations. Two such kilns are the Missouri kiln constructed of concrete, metal and/or masonry, and the batch retort kiln built from several oil drums. Energy efficiency and speed of operation (20-42 hours per batch) are an advantage of the fixed kiln systems. These methods also allow

FIGURE A-8

BURNS & BLANE (KENYA) LIMITED



MARK 'V' CHARCOAL KILNS

SPECIFICATION

Locally manufactured charcoal kiln of all steel construction.

Body: The body is made in three sections of 12, 14 and 16 gauge MS plates with rings to hold one section to the other

Dimensions: Height 7' - 0", Diameter 7' - 10", weight 1,400 lbs

Output: 24 - 32 bags of charcoal in a 72 hour cycle depending on type of wood and operator

Operation: There is one main chimney and four combustion flues with ground level air ducts. An instruction pamphlet is provided with the kiln.

Finish: It is thoroughly wire brushed and untreated.

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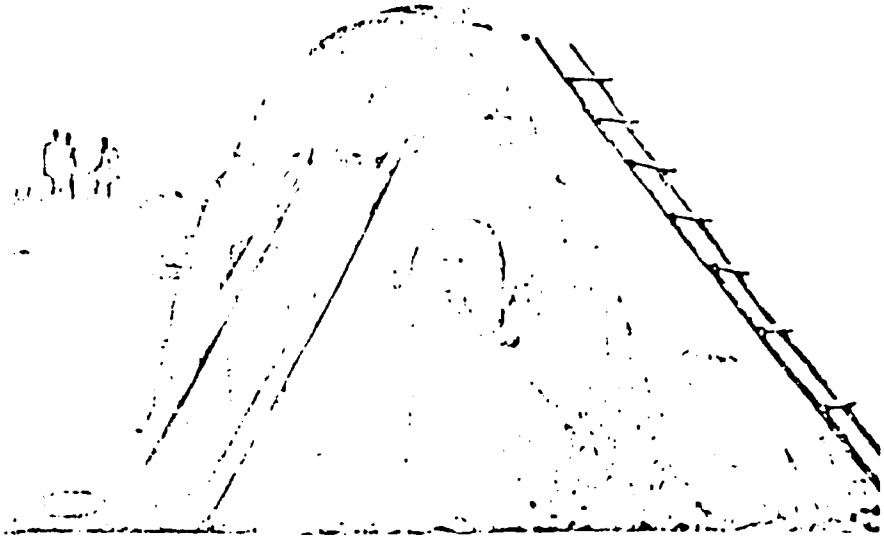
Figure-9

Massive 60-ton Brick Industrial Kiln located at East Africa Tanning Extract (EATEC) Ltd, Eldoret, Rift Valley Province.



Loading Chamber of EATEC Kiln with tractor-hauled wattle logs to left background

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for the potential recovery of tar. However, even such "small-scale" systems (200-300 tons per annum) far exceed the size of traditional kilns, capital costs are beyond the reach of traditional producers, and--most important-- such stationery kilns require a system of small-scale sustained yield production with which there is no recent experience in Kenya.

E. Technologies Not Included in the Project

Pyrolysis to Produce Multiple Products

Small scale pyrolysis processes are being experimented with in Ghana[1] and other countries. The equipment used for these processes is made from old drums; raw materials include sawdust, peanut shells, coconut husks, and other cellulosic materials. The processes produce charcoals, pyrolytic oils, and burnable gas. Serious problems have been encountered in achieving operational reliability and in stabilizing the oils. Also, the projected costs are quite high compared to conventional technologies. Some raw materials such as sawdust produce powdered charcoal which must be briquetted, adding further to the cost. This technology is likely to remain in the research stage for a few more years and thus is considered outside the scope of this project. A small pyrolosis research effort is being initiated at the University of Nairobi and should be monitored by the MOE.

F. Project Needs

Expert Assistance and Training

A long-term expert will be provided to assist the Forest Department, Ministry of Agriculture, and NGO's in promoting adoption of efficiency improvements by traditional charcoal producers. This person will serve the dual role of cookstove and charcoal expert since both areas require somewhat similar technical and extension experience.

Assistance should include development of training courses and materials for the Forest Training School, Farmers' Training Centers, and other appropriate institutions; presentation of workshops for Forest Conservat , RAES officers, and agricultural officers; and workshop training for the Peace Corps or for NGO's that potentially can reach both licensed and unlicensed producers. Also, the project would assist in the preparation of simple illustrated pamphlets--and possibly workshops--aimed at charcoal producers themselves.

1) See T. I. Chiang et al, "Pyrolytic Conversion of Agricultural and Forestry Waste in Ghana", Georgia Institute of Technology.

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Assessment

The long-term charcoal expert and long-term energy planner should assist the MOE and Beijer Institute in analyzing the sociopolitical and resource management aspects of alternative GOK charcoal production policies. They also should monitor and assess charcoal projects underway in Senegal, Mali, Rwanda, the Sudan, and elsewhere in Africa. Finally, the charcoal expert would assess the feasibility of using briquetted agricultural residues

Applied Research and Demonstration

In addition to innovative small-scale charcoal production technologies, the Energy Development Fund should be available to support 1) promising approaches to provision of incentives to encourage charcoal producers to take responsibility for the area of forest from which they secure their raw materials and 2) promising extension and feedback approaches.

IV. WATER PUMPED BY RENEWABLE ENERGY

A. Introduction

Currently, roughly 15% of Kenya's rural population is served by community water supply systems. Most such systems are pumped supplies from boreholes, rivers or shallow wells. Most rural pumps are driven by diesel motors or electricity, with a few driven by wind waterpower and human power. Gravity feed systems have been installed in areas where the source of water is suitably higher than the population served. In addition some rainfall catchments have been constructed on roofs of community buildings and individual homes. In a sampling of 337 water supply systems in 25 districts, 306 pumps were driven by diesel motors, 24 by electric motors and one by a windmill. Of the remaining systems, 5 were gravity feed and one used a hydraulic ram.

The 1979-83 Development Plan sets as a target startup of 100 new Ministry of Water Development rural water supply schemes and 120 new Harambee self-help water supply projects, increasing the rural population served from 1.5 to 4 million persons. Renewable energy systems* may be more economic than competing diesel or electric pumpsets for many of these applications, especially smaller ones. Renewable energy systems also may ease currently severe pumpset operating and maintenance problems. Windmills have the additional benefit that they may be manufactured locally, thus reducing foreign exchange costs for not only diesel fuel but also the diesel motors.

B. Diesel and Electric Pumpsets

Diesel pumps range in size from a fraction of a kilowatt to 100 kilowatts and greater, with the most common sizes being from 2 to 20 kilowatts. The costs of operating and maintaining these motor-pump combinations has been escalating rapidly in recent years, due primarily to fuel cost increases and increasing parts and labor costs.

* Particularly windmill and hydraulic systems

In most installations the operation of a diesel powered pump for 8 hours per day for 3 years costs more in fuel payments than the amount originally paid for the pump. In addition, most district water engineers report serious problems with diesel pumpsets. Some experts estimate that only about one-third to one-half of rural diesel pumpsets are likely to be in operating order at any one time, due to the high frequency of pump or motor breakdowns.

A skilled mechanic is needed to ensure proper system operation, and the Ministry of Water Development does not have the staff of trained technicians necessary to ensure proper maintenance of even its own water supply systems. Other problems associated with diesel-operated pumping units include numerous instances of theft of diesel fuels and, recently, theft of the complete motor-pump combination. Particularly for rural domestic water schemes but also for many irrigation schemes, very few diesel pumping systems have a back-up unit in case of motor or pump failure. In the event of pump breakdowns, the population, simply has no access to the water supply system.

Electric pumps pose many of the same problems as diesel units, although they generally have a better outage record. Because they must be located very close to existing electricity lines, their applicability to future rural water supply systems (often in remote areas) is limited.

C. Windpumps

1. Kenyan Experience

Windpumps have been used in Kenya for a number of decades and have been providing water for livestock and domestic use over wide areas of the northern central regions of the country, with lesser penetration into the coastal and western areas. Many of these windpumps were replaced, beginning in the 1950's, by the what were thought to be convenient diesel pumps. Recently, however, there has been renewed interest in windmills. To extract energy from the wind, a wheel made of spokes and blades is made to rotate about a shaft which drives the rest of the mechanism. Typical wheel configurations are "American Farmmill" type in which the sails are made of galvanized sheet metal shaped in an aerodynamic curve, the Cretan Wheel which uses metal or wood spokes and cloth sails, and the modified turbine type which uses sails or either sheet metal or fiberglass. The gearbox is either a direct stroke or back-geared design. In the direct stroke, each revolution of the wheel yields one complete stroke of the pump. All of the large models, that is more than 16 feet in diameter, use this type of gearbox. In the back-geared designs, the wheel shaft turns a small gear which in turn runs a larger gear at ratios of 3 and 4 to 1. Most machines of 16 foot diameter and smaller are of this type.

The towers used to support these windmills are either three or four legged, welded or bolted together, and usually of painted or galvanized steel. Tower heights which vary to project the wheel above surrounding wind obstructions, generally range between 10 and 20 meters.

The overwhelming majority of windpumps in Kenya today are small diameter back-geared commercially available models. Most of these windpumps have been used to provide water for livestock and domestic use on large farms and ranches, They are generally used in conjuntion with water storage tanks of 30,000 litres capacity or greater.

At least two Kenyan companies currently manufacture windmills. Bob Harris Engineering Ltd. (Thika) produces the Kijito windmill, which uses molded fiberglass blades, and a direct stroke for even its smallest models, in sizes ranging from 12 and 24 feet (diameter). The Kijito mill is particularly suited to "high head" applications (lifting water from relatively deep sources). Thirty units either have been installed or are on order. A newer and quite different windmill--the 12PU 500--is produced by Plows and Allied Products Ltd. (Kisumu). This windmill is more suited to the low-head conditions found around Lake Victoria. After installation, testing, and substantially modifying prototype models, Plows and Allied Products currently is filling an order for five windmills to be used in the Kisumu area.

In addition to local windmills, imported windpumps--including Aermetor, Climax, Comet, Dempster, and Southern Cross--are currently used and available within the country. The commercial windmills imported into the country--specifically the Southern Cross, Aermetor, Dempster and Climax models, are all extermely reliable. Many units installed in the 1920's and 1930's are running as well today as when they were first erected. Their maintenance requirements are minimal - inspection of bolts every six months and yearly oil changes. The two commercial windpumping systems being manufactured in Kenya - the Kijito Windmill and the 12 PU 500 Windmill - do not have the track record of the imported units. However, in the case of the Kijito windmills, the manufacturer has been diligently responsive to field experience to the point that there has been a virutually complete re-design of the original unit as experience has shown up weaknesses.

In addition to the above units, the Mbita Windmill Project of the Catholic Diocese of Kisiihas developed a low-cost windpump for irrigation purposes and is producing it in local workshops on Mbita Island (Lake Victoria). The Project Design Team was unable to see or evaluate this design. There also have been numerous attempts -- bv by the Christian Industrial Training Center (CITC), Peac Corps Volunteers and others -- to design lightweight, inexpensive windmills, with locally available materials in place of steel. These units generally have proven to be understrengt

and unreliable and/or have required substantial operating time and maintenance The CITC, for example, constructed 15 variants of the Cretan sail windmill or Arusha Windmill. Two years later, none of the windmills were operating, and the project was dropped.

2. Wind and Water Conditions in Kenya

Windpumps generally are restricted to areas with average annual windspeeds in excess of 4 meters/second. Where winds are unreliable, provision of water storage is a necessity. The less reliable the wind, the more storage required and consequently the greater the cost.

Gabriel Chipeta's study of wind power availability in Kenya[1] gives monthly and annual maps of surface wind speeds. (Figure A-10). From this map, Chipeta defines two areas of high windspeeds, that is with windspeed averages equal to or greater than 5 meters/second. These areas include a rather small highland zone bounded by the towns of Eldoret, Marigot and Equator, and a much larger band stretching south-east to northwest from Malindi and Lamu in Coastal Province up through Eastern and North-Eastern Provinces following the gap between the highlands of Kenya and Ethiopia to the Lake Turkana area and northern Rift Province. Regions of low annual windspeeds, that is with windspeeds less than 3m/sec., tend to be around Lake Victoria and parts of Central and Rift Valley Provinces.

Seasonal variations of winds, both in speeds and directions, tend to be dominated by the South Monsoon (which begins to establish over Kenya in April, reaches maximum development in July and disappears in October) and the North East Monsoon (which appears in November, attains maximum development in January, and disappears by March). Wind speeds tend to be at maximum during peak Monsoon periods.

Diurnal variations in windspeeds have been analysed superficially. Windspeeds tend to be low during early morning hours and late evenings, rising to a peak in the late afternoons between 1500 and 1800 hours local time.

The Chipeta study also includes a preliminary map of average annual wind power patterns (Figure A-11), which parallel areas of high average windspeed with only minor modifications. This data must be interpreted with caution since many stations make only visual observation of wind speed, reporting stations are not spaced uniformly across the

1) Gabriel B. Chipeta, "A Study of Wind Power Availability in Kenya; University of Nairobi M.Sc. Thesis, 1976.

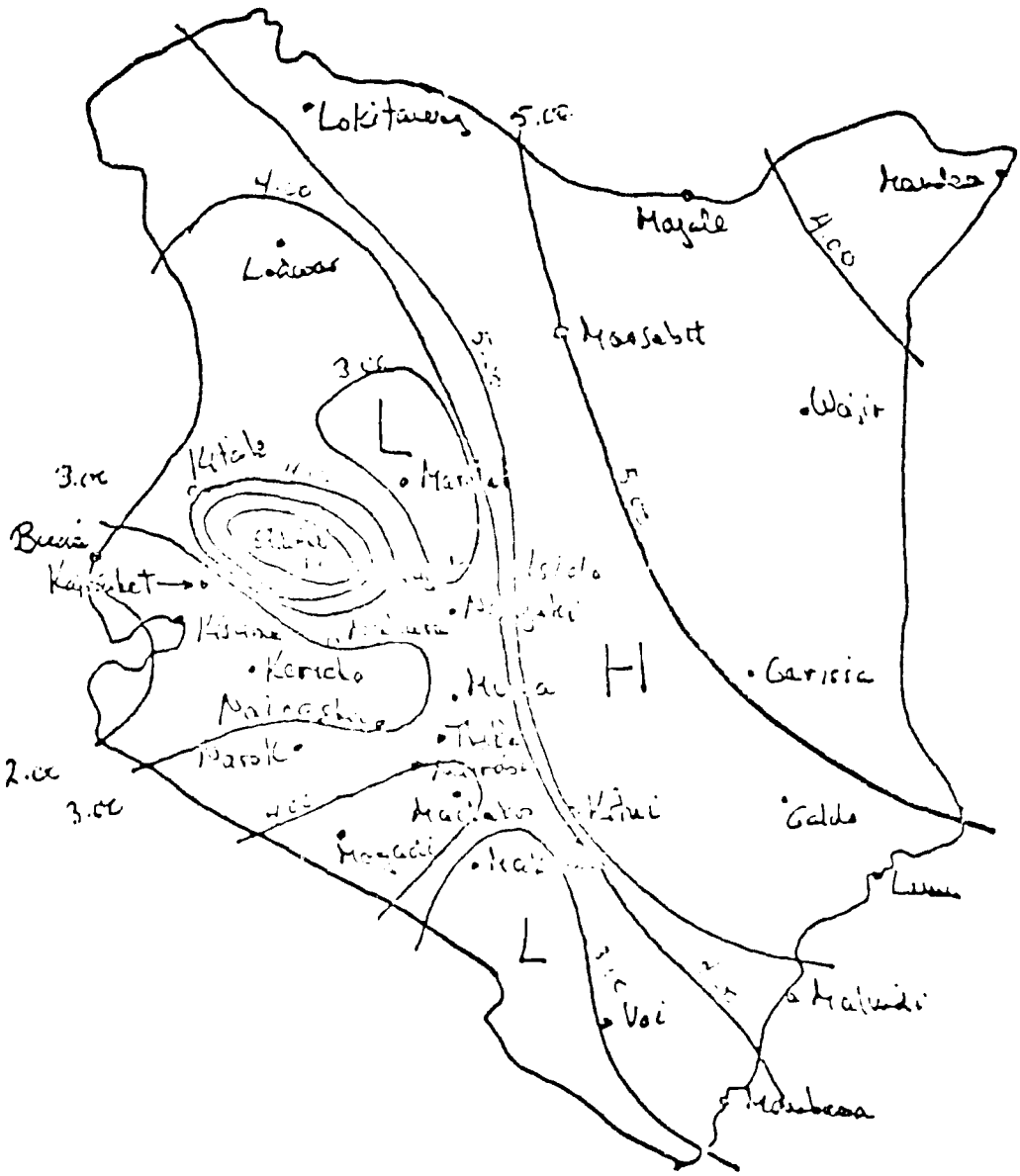


Figure A-10; Average Annual wind speeds in Kenya - in metres/second

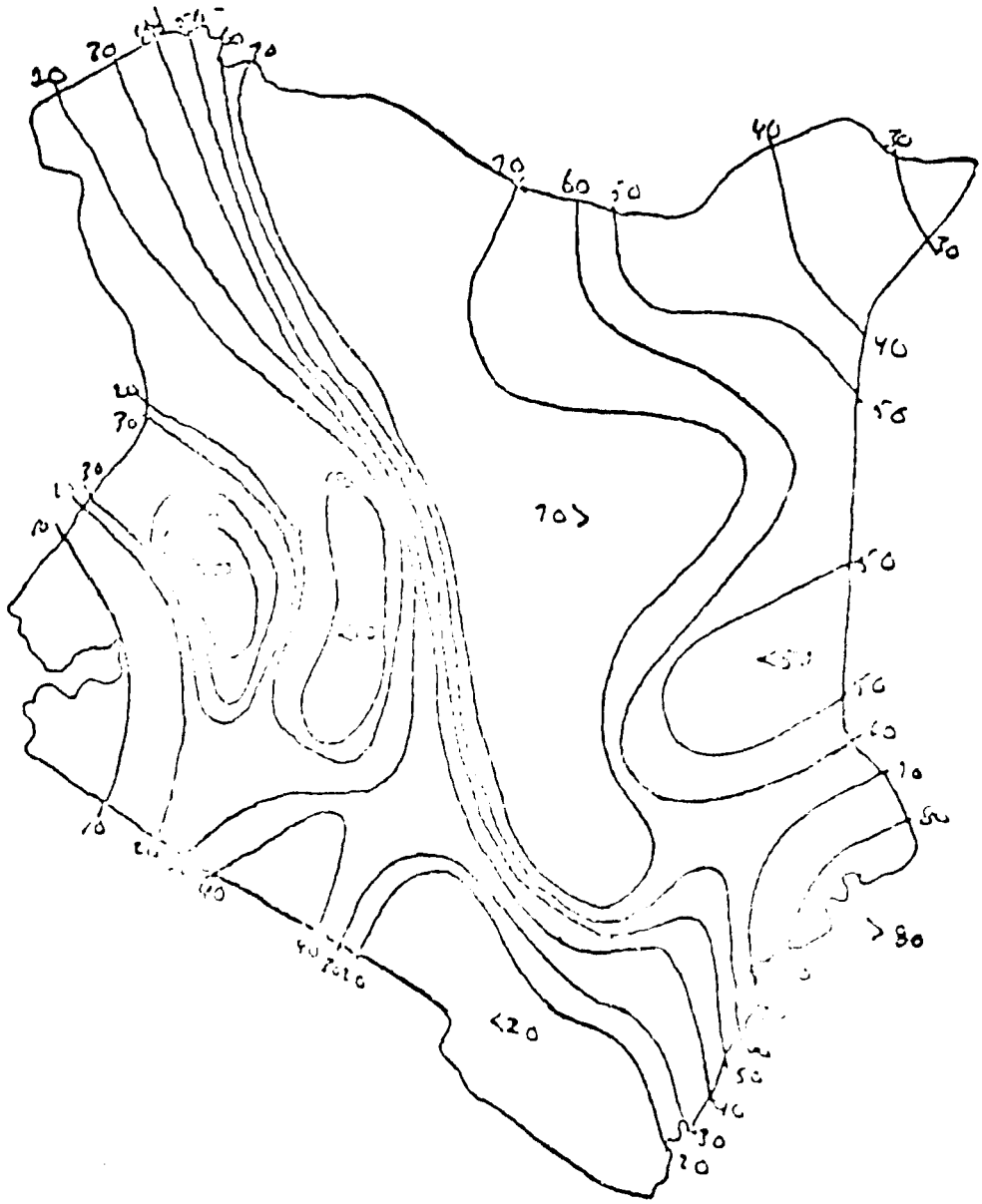


Figure A-11 Average Annual Power (in watts/metre^2) available in Kenya

country, and most stations observation times do not take into account peak diurnal variations. The MOE and Meterological Department have initiated a project to update and expand Chipeta's analysis, but they too will rely on essentially the same type of observational data.

Relative to diesel or electric pumps, windpumps -- which generate less power than most commercial diesel or electric units-- also are best suited to low-head applications (that is, to pumping of water from relatively shallow wells). Unfortunately, data on aquifer depth in various parts of the country is virtually nonexistent. It then is not possible to generalize about suitable site conditions for windmills, since only one of two required parameters--wind availability-- is known.

D. Water Powered Pumps

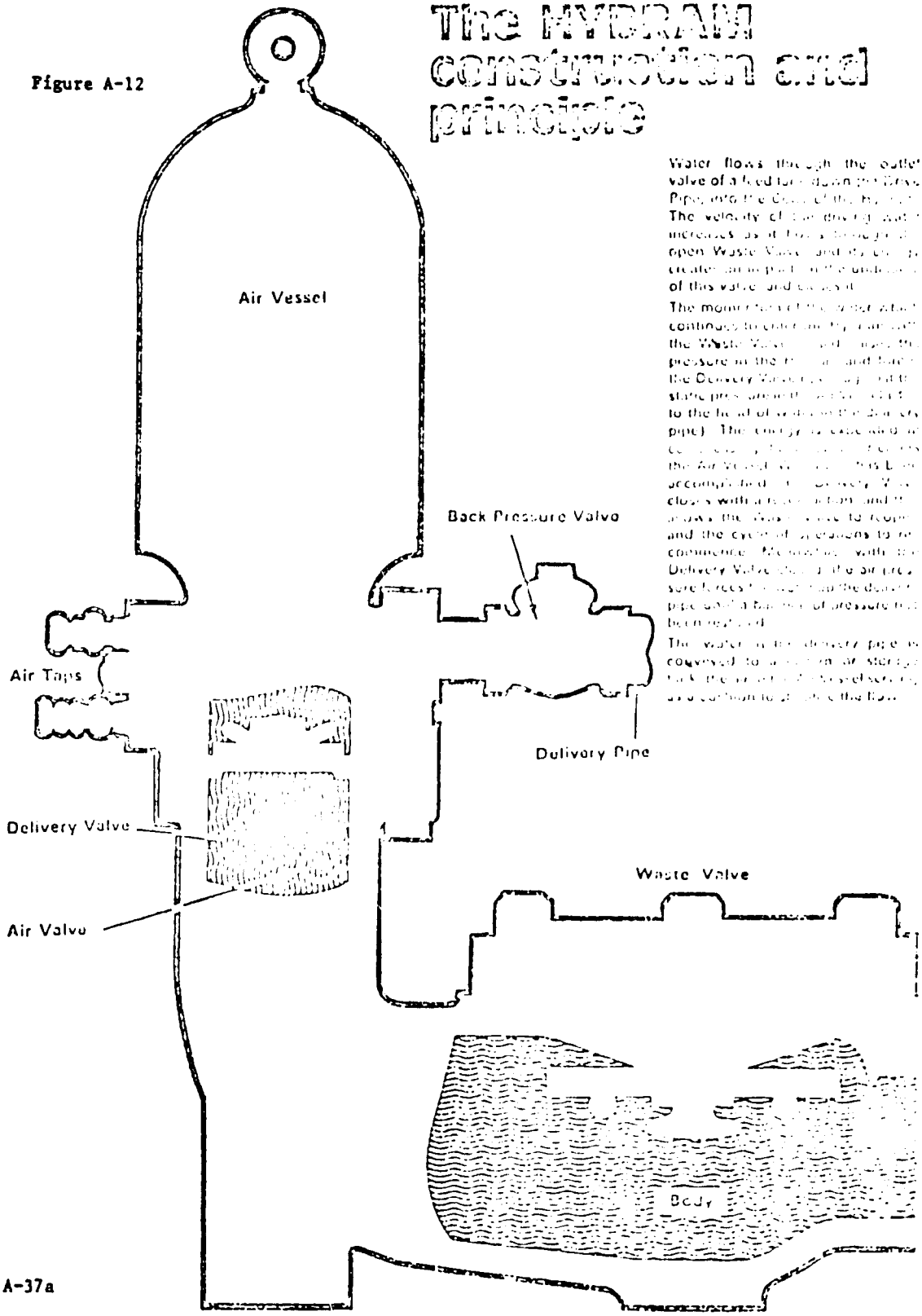
Water power as a means of pumping water is an underused technology in Kenya. One system predominates - the hydraulic ram. Hundreds of hydram units, almost all supplied by Tolen Blake Company of the U.K., are in operation throughout the country, with several dozen new systems being sold every year.

Hydrams have potential applications where relatively small amounts of water must be pumped uphill to serve people living above a flowing river or stream, who thus could not be served by a gravity feed system. A number of conditions are necessary for the operation of a hydraulic ram. There must be a river or stream with a fall of water available (called the working fall) for the system to operate. In addition there must be an excess of water flowing down the drive pipe, over and above that which is delivered for use through the delivery pipe, (Figure A-12 &13). Both of these factors will determine the height to which the delivery water can be raised and the volume of this water. The working fall is generally limited to between 1 and 15 metres and the height to which delivery water can be raised is limited to between 3 and 10 times the working fall. Maximum delivery height is about 140 metres. The higher the delivery head, the less the quantity of water delivered. The water delivered is typically 5 to 15% of the water coming down the drive pipe.

Hydrams are inexpensive compared to other pumping systems (although installation costs can be high if feed water has to be channeled for any distance to obtain an adequate working fall), and water quantities delivered and distances pumped also typically are substantially less than for other systems. The largest Blake hydram marketed in Kenya has a maximum delivery of about 400 litres per minute and a maximum pumping height of roughly 100 metres.

Figure A-12

The HYDRAM construction and principle



Water flows through the outlet valve of a fixed fall down pipe (Drive Pipe) into the [illegible] of the hydram. The velocity of the driving water increases as it flows through the open Waste Valve and its [illegible] creates an upward force on the underside of this valve and closes it.

The momentum of the water which continues to [illegible] through the Waste Valve [illegible] increases the pressure in the [illegible] and forces the Delivery Valve [illegible] against the static pressure which [illegible] to the head of water in the delivery pipe). The energy is [illegible] in the Air Vessel [illegible] This is accomplished [illegible] Delivery Valve closes with a [illegible] and it allows the [illegible] to flow and the cycle of [illegible] to recommence. Meanwhile with the Delivery Valve closed the air pressure forces [illegible] the delivery pipe and a [illegible] of pressure has been created.

The water in the delivery pipe is conveyed to a [illegible] air storage tank [illegible] and cushions the flow.

A-37a

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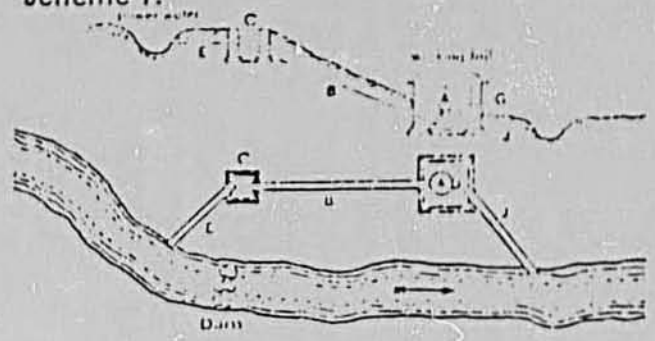
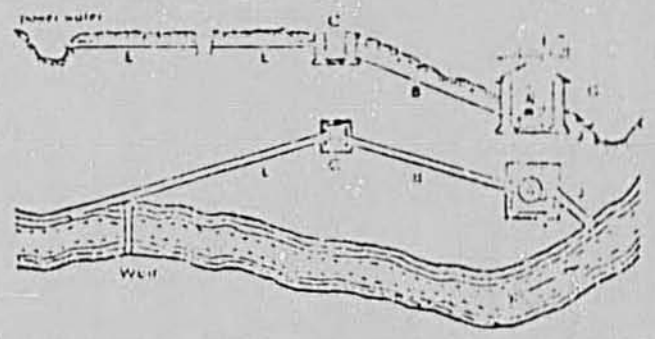
Basic requirements for a HYDRAM installation

Figure A-13

Scheme 1.



Scheme 2.



When investigating the possibilities of a proposed Hydram site a number of basic requirements must be examined. Most important of these is that there must be a reliable continuous supply of flowing water. Secondly, that a working fall or difference of levels of not less than 1 metre (39 inches) can be obtained. It should not however exceed one-third of the vertical height to which the water is to be pumped, and proposals in which the working fall exceeds 15 metres (50 feet) should be referred to the Works. Finally, in order that waste water may drain away, the top of the waste valve of the Hydram must be higher than the level of the water into which it drains.

APPROXIMATE CALCULATIONS

There are four items involved in the operation of a Hydram, namely —

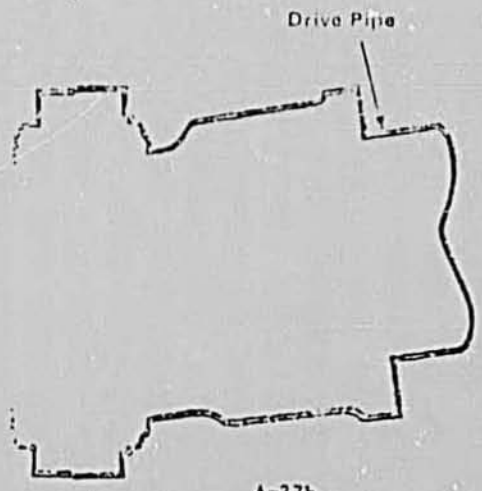
- V Volume of water to be raised per minute.
- H Height to which the water is to be raised.
- F Working fall which is available.
- D Volume of driving water required or available per minute.

If it is required to find the value of V, other items being known, the formula to use is

$$V = \frac{2}{3} \cdot \frac{D}{H} \cdot F \quad \ldots \quad (1)$$

To determine D, knowing the other three items, the formula becomes

$$D = \frac{3}{2} \cdot \frac{V}{F} \cdot H \quad \ldots \quad (2)$$



A-37b

IN APPLYING THESE FORMULAE UNITS OF FEET AND GALLONS OR METRES AND LITRES SHOULD BE USED. THEY MUST NOT BE MIXED. THEY SHOULD BE ALL BRITISH OR ALL METRIC.

Examples

(1) Given that D = 25 gall. per min, F = 15 feet, H = 200 feet.

$$V = \frac{2}{3} \cdot \frac{25}{200} \cdot 15 = 1.25 \text{ gallons/min}$$

It will then be apparent if this volume is sufficient for the application.

(2) Given that V = 6 litres/min., F = 6 metres, H = 80 metres.

$$D = \frac{3}{2} \cdot \frac{6}{6} \cdot 80 = 120 \text{ litres/min.}$$

It will then be necessary to confirm that this volume of driving water can be supplied.

This is only an approximate check, but if the result indicates that a Hydram installation seems feasible, reference to pages 4 & 5 will give an indication of the size of Hydram which would meet the conditions.

You are invited to complete and post the enclosed Enquiry Form, upon receipt of which we (or our Agents) will assess the application and submit a firm quotation.

To ensure that the Hydram is correctly installed, we strongly recommend that the site survey and Hydram installation are carried out by engineers experienced in this type of work. We will be pleased to offer these services to customers in the United Kingdom.

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Although they have very few moving parts except for simple valves, hydrams have encountered operating and maintenance problems. Of the hydram units assessed by the Project Design Team, roughly half were out of service due to failure to replace worn rubber clappers or to clear intakes or because the large brass waste valve (which has a high value as scrap) had been stolen.

With proper routine maintenance, hydrams will operate unattended. The system should be periodically checked, usually once per week, to ensure that trash is not blocking the intake, that all connections and bolts are tight and that the waste valve is working properly. Rubber clappers on the waste valve must be replaced roughly every 2-3 years. Other than that, periodic bleeding of the air taps is the only other necessary operation. Under such conditions hydraulic rams typically will provide satisfactory service for several decades.

Hydrams can satisfy a need for community water supply system near a river or stream where the volume of water required is low-- which describes many Harambee self-help water projects on hillside slopes or river or stream valleys. Their use should be supported through the provision of technical assistance in equipment selection, installation, and maintenance.

E. Human and Animal Powered Pumps

Handpumps are not common in Kenya, but they are used, particularly in remote locations. Foot-operated and animal-powered pumps were not discovered by the project team. Handpumps are available in a wide variety of options. Most are of the reciprocation piston type which are most suited for use in a well or borehole. Other handpumps include semi-rotary, clapet, and chain and washer pumps. The last pump can be made in small workshops from a variety of materials, to low construction tolerances, and by relatively inexperienced technicians.

Handpumps in general have a record of unreliability when used in community well water supplies. Even the more robust tend to break down with hundreds of people continually using them. A few handpumps require two persons to operate them. These typically are used for small irrigation schemes in various parts of the world. Breakdowns in these pumping systems are infrequent, possibly because fewer people operate them.

Two types of foot pumps have been shown to provide reliable service over the years. One is a bellows pump promoted by the International Rice Research Institute in the Philippines and manufactured and sold by a number of companies in that country. The other is the Vergnet hydro pump. Both of these pumps require minimal maintenance. Foot pumps make use of human power most effectively since leg muscles are stronger than the muscles in the upper part of the body.

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Animal Power

Animal power is widely used for pumping in many parts of the world. Draught animals if they are well looked after and the equipment is suitable, can make a substantial contribution to irrigation farming. Common animal powered devices range from a draw rope pulling a water-filled leather bucket up and out of a well, to vertical axis geared turbine pumps. In between are a variety of devices which deliver constant loading to the pump through some type of power take-off gearing. This gearing can vary from simple timber cogged wheel to specially manufactured steel cam and pinion gears. The chain and washer pump described earlier can be adapted, through horizontal to vertical gearing, to animal power. Very little activity is underway to promote the use of human powered pump for domestic water supplies in Kenya. A few distributors carry handpumps, and the Karen VTU has on display two handpunps ranging from shallow well clapet and hand chain pumps to deep well pumps.

F. Solar Distillation

In the simplest case, a solar distillation unit is a shallow pond with a black colored basin liner. Over the pond is placed a sloping glass or transparent plastic cover through which the sun's radiant energy passes, heating up the saline or brackish water in the pond. Water evaporates and condenses on the cooler sloping transparent glazing, flows down into narrow channels along the lower edge of the cover and is led off to collect in a reservoir, from which it is distributed.

Solar distillation units can be constructed, maintained and operated with village level skills. Local materials can be used in the construction, e.g. sand and rammed earth blocks. Minimal operation and maintenance instructions are necessary since both functions require very little time and skill to perform. Major maintenance concernsinclude adequate protection against salt crystallization, corrosion of pipes, and glass breakage. Typical maintenance procedures include cleaning dust off the glazing and ensuring that pipes and channels are not blocked.

Solar distillation units require a relatively high capital investment per unit capacity. However, if well designed and constructed, recurrent costs are very low.

Solar stills are usually constructed where drinking water sources are extremely limited, and thus where people tend to be very conservative in their water use patterns. Typical consumption rates from solar distillation plants are 4 to 5 litres/person/day of potable water.

Available solar radiation data indicates that a reasonable production rate can be maintained on a year round basis in many dry lowland areas of Kenya. In particular, this technology could meet a high priority

need in significant areas of arid northern and northeastern Kenya, where ground water is available but most is highly brackish. Storage reservoirs will be necessary to supply 3 to 4 days demand in most areas.

Solar distillation work has been undertaken, for the most part in a research capacity, at a number of locations. The first experimental solar still was set up at Kilifi during the 1950's, another at the Divisional Police Headquarters of Turkana in 1959. Other activities have included the installation of two stills at Kapedo Mission, north of Lake Baringo, each 10 square metres in size and an Australian/Kenyan project near Malindi. Several researchers at the University of Nairobi have worked on solar stills over the past decade. These include Mr. H.DeSousa of the Department of Electrical Engineering, Mr. R. Haskell of the Department of Civil Engineering and Mr. Z.Ngcakaru of the Environmental Health section of the Department of Civil Enginerring. A study entitled, "Solar Distillation for Developing Countries: An Engineering and Economic Evaluation" by A.S. Akishula was completed in June, 1980 as a M.Sc. Thesis in Environmental Health Engineering at the University of Nairobi. In addition to this activity, the Karen VTU demonstrates a small solar distillation unit.

G. Solar Pumps

Solar pumps are of two types: thermodynamic and photovoltaic. The thermodynamic systems, typified by the Rankine cycle "Sofretes" pump, generate power bases on the temperature difference between a solar heated fluid and the cold ground water. The apparatus to accomplish pumping from such a thermodynamic cycle is sophisticated and expensive.

As with all sophisticated technologies, these pumping systems require a considerable amount of maintenance and upkeep to keep them working. The level of technical expertise required for such maintenance is high, thus, if they are tobeused they must be sited where adequate technical service is available. Experience to date with these systems has been variable. Where technicians are sufficiently trained and available, these pumps operate satisfactorily. Where technicians must be brought into, for example, remote areas, these pumps have had major maintenance problems and system shut down is common. A Sofretes pump unit was installed atWajir in 1977. It operated for only a short time before mechanical and operational difficulties forced shutdown.

Photovoltaic pumps, on the other hand, are reliable, require little maintenance beyond routine inspections and fit in more with conventional maintenance and operation procedures. However, they are costly. Present costs are about $10 to $20 per watt of installed pumping capacity. However, this cost is dropping rapidly. They are expected to be economically competitive with other pumping systems within 5 years for accessible sites and are marginally competitive even today for remote sites. The pumps associated with photovoltaic arrays are conventional electric water pumps.

Experience to date has revealed that maintenance is minimal and the systems are well accepted where they have been installed. They depend on the availability of adequate direct sunlight, so their areas of use for year-round water provision will have to be carefully selected.

This project excludes solar pumping for a number of reasons. First, it would seem wise to wait until photocell costs come down to the point where photovoltaic pumps can be more economically substituted for fossil fuel driven systems. Second, two other groups already are investigating the use of photovoltaic systems. NASA Lewis sent a team to Kitui District in July 1980 to assess the feasibility of using photovoltaic systems in AID-financed health centers and in water pumping in certain remote locations, and it appears that some installations will be made as a result of their recommendations in the Machakos area. In addition, the Small Scale Irrigation Unit of the Ministry of Agriculture is currently purchasing and installing two small photovoltaic systems from Solar Electric International for an irrigation project near Garissa. These systems will be compared on operational, maintenance and economic bases with other commerical pumping systems. It would be prudent to await the outcomes of both of these projects before deciding to go ahead with further installations. Finally, the MOE believes that a number of donor governments--including, through the DOE, NASA, or SERI, the U.S.--will be offering to install solar pumping units on a demonstration basis because of their long-term commercial interest. This project thus can best be used for other renewable energy technologies where such commercial interest does not currently exist.

H. Project Needs

Organizational, financial and maintenance problems appear to be the greatest barriers to implementation of the government's objective of access to safe water supplies for all rural Kenyans by the year 2000. If the objective is to be reached, greatly accelerated programs will have to be implemented by the Ministry of Water Development, other government agencies, private voluntary organizations, missions and harambee groups. Within these accelerated programs some of the problems can potentially be resolved through the use of less complex technologies, intensified reliance on renewable energy systems and attention to a local technician/maintenance infrastructure.

This project is directed toward these areas of need. It also takes into account the activities of other donors--specifically including the FRG's plans to install a number of Windpumping systems in Lamu, Kilifi, and Turkana Districts, and the Dutch Government's provision of a wind expert to the MOA Small-Scale Irrigation Unit for three months--and likelihood of substantial donor interest in installing solar pumping units.

The project will provide a long-term expert in renewable energy applications for water pumping and in maintenance and other technician-level aspects of water supply. The expert's primary responsibility will be to assist the Ministry of Water Development, the MOA Small-Scale Irrigation Unit, Harambee groups, and NGO's involved in water supply, to review its projected new water supply system installations, develop criteria and evaluation methods for identifying specific systems for which renewable energy would be the best source of motive power, and establish training and technical assistance programs for field Water Engineers and technicians. The expert also will work with the above groups to develop promising projects to be supported through the Energy Development Fund. Other specific tasks include:

- A survey of windmill, hydram, and other renewable energy hydraulic ram installations throughout the country, carried out in conjunction with extension visits to at least the major District address:

  - the number of working/nonworking installations

  - ownership of the installations

  - communities served by these installations

  - working installations' output and reliability

  - for non-functional systems, - the reasons for not working

    - the replacement water source, and
    - level of enthusiasm for reinstating the original system

  - nearest access to replacement parts

  - availability of people knowledgeable about, and capable of providing routine maintenance.

  - willingness of more than one community member to take part in a demonstration workshop on operation, maintenance and repair of such systems.

- review of MOWD and other agencies proposed water schemes to determine where proposed new diesel pump installations could be feasibly replaced by small windpumping systems. The agency could then apply to the Energy Development Fund for a demonstration grant or finance the system itself.

- assistance in system and site selection and technical/cost analysis for specific installations.

- Assistance in repair and maintenance on some or all of those surveyed systems which have need of such service and from which communities' members participating would, under the supervision of trained technicians, undertake some or all of the necessary repair and maintenance.

- Depending upon level of interest, assist in establishment of in-depth training courses(4-6 weeks) and shorter workshops, both aimed at technician training. Training programs could be molded after the short course offered by New Mexico Solar Energy Institute of the University of New Mexico, Las Cruces, New Mexico. The cooperating government agency (most likely MOWD) would be responsible for provision of training equipment including windmills, hydrams, etc.

- Monitoring and evaluation of experience with units installed, particularly with respect to operations and maintenance experience, and with local receptivity to alternative extension and assistance approaches.

V. WATER POWER FOR LOCAL INDUSTRY

A. Introduction

Water power long has been used in Kenya to operate grist mills (posho mills), pump water, run sawmills and generate mechanical shaft power for other purposes. In the late 1920's it also began to be used to generate electricity. During this early period water power development was characterized by small demands met by isolated plants on small rivers and streams, with outputs rarely exceeding 3 to 4 Kilowatts. The least sophisticated, yet most reliable of these posho mills, were and are typically found where grinding of maize or other grains was required and reliable year-round flows or water could be channeled into 5 to 8 metre falls.

Perhaps because locations may be inconvenient--since they must be sited where the water has an adequate head, often on steepslopes, in ravines and valleys--most water-powered mills have been replaced by small diesel-powered grist mills. Similarly, with the availability of low-cost diesel-powered units of the electric utility grid, sawmills and other water-powered operations largely have shut down.

With the high and rising costs of diesel, there may be some potential for re-starting older small-scale water-powered industrial operations or designing new facilities. The level of interest or feasibility, however, currently is unknown.

B. Posho Mills

There are no reliable estimates of the number of water-powered posho mills still operating. The Design Team visited two operating water-powered mills in Nyeri and Karatina. Water Department officials in Nyeri told of 4 other functioning sites in the Aberdares Mountains to the west and south of Nyeri. Other Water Department people told of several working units in Western and Nyanza Provinces and in Eastern Province near Meru. The number of non-functioning sites is also unknown. The only approximations generally obtained were"many" and "hundreds".

While posho mills designs vary, most water is channeled from upstream to a location where the water drop is about 5 to 6 meters. Open channel or pipe penstocks then direct the water at a wood bladed impellor mounted beneath the floor of the building housing the mill, and is directly coupled, through a stationary stone, to a rotating grindstone roughly one meter in diameter. The grain is fed via a hopper into the space between the two stones and the ground flour is thrown out around the perimeter. This flour is then swept off the floor and given back to the client.

The rotating grindstone is adjustable up or down on the axle from the impellor, to give a variety of fineness. The impellor speed is controlled by the quantity of water striking it, which in most cases can be adjusted by a sluice gate arrangement at the entry to the penstocks. One operator is required full time for each grinding wheel in operation.

The posho mills typically are fairly slow. It can take 15 minutes to grind 4 kilogram of flour. Diesel powered units take only a fraction of this time. During periods of low water availability the units can have less power output and the grinding time is proportionately longer. The impellors are quite inefficient and waste substantial. However, these systems make use of a naturally recurring energy form, their operation is easy to master and maintain, and repairs can be carried out by the operator at the site. The impellor has wooden blades which are individually replaceable from local materials, the grindstones are hand-crafted from stone quarried in Kenya, and all channeling and ducting are built on -site of locally available materials.

C. Other Water-Powered Applications

Team members were unable to verify the existence of a single working water-powered sawmill anywhere in the country, although two shut-down mills were observed. Diesel power, either in the form of stationary motor sets or tractors, and other portable machinery, began to replace water power to operate sawmills after the Second World War.

Waterpower has been used to generate electricity for delivery to the grid or by farms or ranches to provide lighting and appliance and machinery operation The farms and ranches used small units of 2 to 10 Kilowatt capacity on streams with adequate year round flow and fall. A number of such units, some of very sophisticated design (e.g., Francis turbines), still are in place although they no longer operate. On a larger scale, the Tana River has several developed and potential sites particularly in that part of Kenya stretching for 160 km. down stream of the Lower Tana Power Station between Sagana and Thika. The river drops steeply and a major reservoir on the upper river can control a natural storage area which can regulate flow for downstream power generation sites. Because of their proximity to Nairobi, most such sites will be used for electric power generation.

D. Project Needs

Potential electric power sites on the Tana River already have been identified and evaluated, and a team of Finnish experts shortly will begin a survey of potential micro and mini hydroelectric sites in Western Province. This project therefore should concentrate on direct-drive rather than electric power applications. The renewable energy/water supply expert should:

- Survey existing functioning and non-functioning water-powered posho mills and other direct-drive units. This study will document for operating units the availability of local capability to create and maintain the systems, their working condition, number of clients using the services, the economics of operation, and convenience to clientele served verses competitive diesel and electric posho mills nearby. For non-working installations, information to be gathered will include reasons for abandonment, local capability to repair, operate and maintain the system, physical condition of the mill and its major components, potential clientele, enthusiasm for re-installing the system and an assessment of the costs to re-furnish the unit. The study would provide a data base from which to assess potential impact of any schemes to upgrade, existing water powered posho mills. It also would involve an assessment of the potential rural economic development impact of efforts to stimulate new water-powered operations. Finally, it could regenerate interest in an established technology which is fast disappearing.

- Depending on the outcome of the above survey, work with existing posho mills operators, Kenya Industrial Estates, and others to both improve or restart existing water-powered operations and stimulate investment in new operations.

- Consider partial funding of one or more demonstration projects, including installation of a more efficient posho mills using improved impellor blade and outlet jet designs and metal grinders, under the Energy Development Fund.

VIII. SOLAR DRYING

A. Introduction

Solar drying is a widespread technology in Kenya, as in other countries. Grain drying is extensive, mostly in the open sun, as is fish drying in areas such as Lake Victoria and Lake Turkana. Few vegetables and virtually no fruits are dried. Commercial drying--solar, fossil-fuel, or using agricultural wastes--is practiced for tobacco, tea, coffee, and pyrethrum.

Existing drying techniques often reduce product quality, particularly of fish and cash crops and increase storage and transportation losses. For example:

- Maize is often harvested at 19% moisture and placed in a crib where it is expected to reduce its moisture content to an acceptable 13%. The structure of the crib generally is such as to inhibit further drying and the moisture content is suitable for rapid mold growth. Mold also develops as a result of field drying conditions. Also, production of aflatoxins can be increased by the intermittent wetting and drying caused by rains and sun. Finally, the long post-maturity period in the field is particularly favorable for insect infestation and rodent damage.

- The current method of drying fish with open sun provides ideal conditions for insect infestation. Losses are estimated to be as high as 50% or more.

- Open sun drying of coffee and pyrethrum lead to some contamination due to dirt, grit, etc.

In addition, for cash crops, open rack sun drying normally is a preliminary step, followed by drying in hot air chambers or otherwise heated enclosures using fossil fuels.

Improved solar driers potentially can improve product quality, reduce storage and transportation losses, and reduce fossil fuel consumption.

B. Current Activities in Kenya

The recent AID "Kenya National Crop Storage Study" recommended both modification or traditional practices to produce drier grains for storage and experimentation with a portable clear plastic drying roof. The FAO conducted some experiments with cribs using open-air drying and solar collectors but reached no conclusions. The University of Nariobi, as part of the Commonwealth Secretariat's African Energy Program, is initiating a three-year program to develop small-scale grain driers and large-scale driers for cooperative societies handling pyrethrum, coffee, and tea. The Kenyatta University College

has done some experiments on solar air driers for maize. The British American Tobacco Company is experimenting with use of solar dryers for tabacco, and coffee producers are considering such experimentation.

C. Project Needs

In view of the widespread interest and experimentation, the long-term renewable energy expert should monitor activity, provide technical information and assistance to such organizations, try to broaden interest by meeting with cooperatives and other potential solar dryer users, and where appropriate help develop sound Energy Development Fund grant proposals.

IX. OTHER TECHNOLOGIES

A. Other Small-Scale Technologies Appropriate to AID Target Groups

There are a number of other small-scale renewable energy or energy conservation technologies which potentially could benefit AID target population groups. Examples include improved thatch insulation for use by rural households in highland areas, a variety of human-or animal-powered equipment for farm or household use (e.g. maize shellers, grinders), and small water catchment systems such as the water jars demonstrated at Karen VTU. The project intends that these technologies be monitored by the long-term renewable energy experts and be eligible for demonstration grant funding through the Energy Development Fund.

B. Agricultural Residues

It is recommended that the long-term cookstove/charcoal/biomass expert conduct a thorough assessment of generation and current and potential utilization of agricultural and silvicultural processing residues and provide technical assistance where appropriate. Most such residues appear currently to be used beneficially. However, a number of large residue generators, such as Kenya Canneries, currently dispose of large quantities of residues. Others are experimenting with new residue recovery processes. For example, large coffee processors are experimenting with briquetting of the coffee pulp as a substitute to charcoal, and the GOK is pressing for expanded use of sawmill and other wood wastes in production of fiber-board or similar products.

Table A-3 provides estimated quantities of selected high-cellulose (and therefore high-energy content) residues.

Table A-3

Estimated Quantities of Selected Residues

Description	Raw Material	Quantity of Waste Available	Remarks
Forest thinnings or residue	Logs- 500,000 Cu. meter approximately Shrubs, Secondary Species, unwanted trees.	200-225,000 cu. meters	40-45% of logs.
Coffee parchment or coffee waste	80-90,000 tons of coffee beans	20,000 tons	25% of coffee beans
Cashew nut shells	15-20,000 tons of raw cashew nut	10,000 tons	65-70% of raw cashew nut
Saw dust and off cuts	Saw mill timber 350,000 cu. meter	50,000 tons 120,000 tons off cuts	80-90% of sawn timber
Rice husk	Paddy- 40,000 tons	15,000 tons	30-40%

C. Biogas and Power Alcohol Systems

Biogas systems have not been included in the project because, as discussed in Annex C, their high capital costs and technical complexity put them well beyond the reach of AID's target population groups. Also the Federal Republic of Germany and People's Republic of China both have announced their intention to support biogas demonstration projects, while the U.N. and Brazil are providing technical assistance in power alcohol.

The project design team does believe that a project to utilize currently flared methane gas generated at the Kariobangi Sewage Treatment Plant outside Nairobi should be considered for partial Energy Development Fund Support. The plant currently generates 120,000 cubic feet of methane per day as a by-product of sewage treatment. It uses 45,000 cubic feet to fuel its boilers (which, among other uses, provide external heat for the digesters) and 45,000 cubic feet to incinerate sludge and scum. The remaining 30,000 cubic feet, which currently is flared, would be sufficient to provide gas for cooking and other purposes to roughly 150 homes in a nearby low-income area. This quantity of gas is roughly four times the combined theoretical output of all Hutchinson biogas digesters installed throughout the entire country.

The design team separately has provided the MOE with an evaluation of the Hutchinson farm-size digesters marketed throughout Kenya. Most of the units visited, particularly in the highlands, were shut down due to operational problems. The fact that the unit marketed by Hutchinson (as opposed to the one used on his farm) uses an above-ground uninsulated steel tank limits its potential for use in highland areas where temperatures are not sufficiently high to permit proper biological reaction. Figures A-13&14 showthe biogas digesters marketed and used by Hutchinson, respectively.

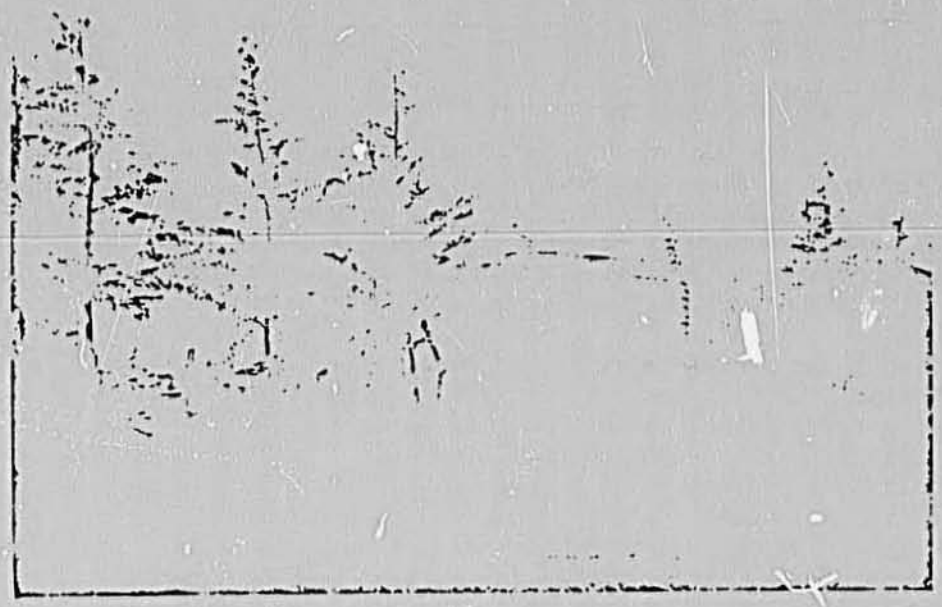

Figure A-13. "15-cow" vertical silo-type continuous feed digester prefabricated by Tunnel Estates, Fort Ternan installed at coffee estate, Meru District, Eastern Province.

Figure A-14. Thirty cubic meter horizontal displacement continuous feed digester located at Mr. Hutchinson's Tunnel Estates Farm, Ft. Ternan, Kericho District, Rift Valley Province.

ANNEX B. SOCIAL SOUNDNESS ANALYSIS

I. POPULATION CHARACTERISTICS, SPREAD EFFECTS, AND SOCIAL CONSEQUENCES

A. Population Distribution, Characteristics, and Modes of Production

About 70% of Kenya's population is made up of various Bantu-speaking groups which are concentrated in three areas: the central highlands east of the Rift Valley, the coastal belt, and the Lake Victoria basin. The largest of these is the group occupying the central highlands east of the Rift Valley; this group includes the Kikuyu, Embu, Meru, Mbeere, Kamba, and Tharaka ethnic groups, which are predominantly agriculturalists. The majority of these occupy the very fertile highlands around Mt. Kenya, Nyambeni, and the Aberdares. The remainder of Kenya's population falls into two linguistic groupings: Nilotic and Cushitic. Nilotes include Luo, Kalenjin, Maasai and related peoples and make up about 25% of the population. Cushitic-speaking peoples such as the Somali, Rendille, and Galla make up about 3% of the population. The remaining 1 or 2% of the population is of Asian, Arab and European origin.

Among the Nilotes, the rural Luo population is primarily agricultural and is concentrated in the lower parts of the western plateau draining into Lake Victoria. This area is characterized by heavy out-migration of adult males, and thus substantial numbers of Luos are also found in major towns throughout the country. Kalenjin and Maasai peoples were part of a series of north to south migrations of pastoral peoples along the west central highlands and are found throughout the Rift Valley area. Though farming is increasingly practiced by some Kalenjin and Maasai, many of them remain pastoralists. The Cushitic-speaking Somali, Rendille, and Galla are largely pastoralists and occupy most of the northern and eastern arid and semi-arid areas of Kenya.

Other rural population concentrations occur only in scattered areas where higher altitude and more reliable rainfall favor agriculture. Nairobi and Mombasa represent about 75% of Kenya's urban population, while most other towns range in size from about 2,000 to 10,000 persons.

Population densities in high potential, highland areas often exceed 400 persons per square kilometer, while densities in the low potential arid and semi-arid lands are often below two persons per square kilometer. Average population densities in medium and high potential areas are about 126 persons per square kilometer. With present technologies only about one-fifth of Kenya's total land area is considered cultivable. Approximately half of the population lives on only about 6% of this area.

There are significant regional differences in levels of economic development and in availability of services such as schools, hospitals, and transportation. In general, road and social service networks are best developed in the high potential, densely settled regions of the country, particularly in the highlands on the western and southern sides of Mt. Kenya. Medium and lower potential areas are considerably less well off than the highlands, but the government is at present significantly increasing development efforts in such areas to help redress regional inequities.

2. Organizations

Soft-loans or grants under either component may be made only to officially constituted organizations, including GOK, NGO's, registered Harambee groups, and private sector corporations, partnerships or sole proprietorship. In addition, the MOE may provide loans from the Fund to the Agriculture Finance Corporation (AFC), Kenya Industrial Estates (KIE), or other official financier agencies who may re-lend to private farmers, private businessmen, or other qualified individuals.

3. Economics

An applicant for either type of loan/grant must show that the technology demonstrated or disseminated can be produced and delivered within a cost range which is likely to make it economically attractive to the potential users. This economic analysis may take the form of a simple payback or discounted cash flow analysis or a cost comparison versus whatever system(s) would be displaced by the technology or technologies being demonstrated or disseminated.

4. Cost Sharing

Grantees or loan recipients must themselves fund at least 25% of the proposed program or project.

II. Program Grants/Loans

Specific Criteria

(1) No single organization may receive more than $75,000 in program grants or loans under the AID-financed portion of the Fund.

(2) Organizations must demonstrate capability and experience in the general field of the loan/grant application. That is, an applicant proposing to test cookstoves must demonstrate an existing test capability, an applicant proposing a tree planting extension must demonstrate proven extension experience etc. Organizations already reviewed by the AID Project Design Team and judged to be generally capable in specific areas are presented in Table H-1. This list should not, however, be interpreted as AID endorsement or recommendation for funding.

(3) No more than one-third of the AID-supported portion of the Fund will be allocated to GOK organizations.

Application Review and Approval Process

The MOE will solicit program grant or loans applications at least annually. The MOE will formally advertise for applications and will meet with organizations such as listed in Table H-1 to solicit interest well in advance of the applications date. Applications will be submitted to and reviewed and approved by MOE, which will hold the Authority to Incur Expenditures (AIE). Loan/grant approvals will be signed at the Deputy Permanent Secretary level or above.

lower in lower altitude zones where the more profitable cash crops listed above cannot be grown. The population is most heavily concentrated in the medium and high potential agricultural areas, though population pressure on land is not leading to some agricultural expansion into more marginal, lower potential areas.

Smallholders as a group have an average household size of about seven persons and a median annual income valued at between 2,000 and 2,900 Ksh., with a mean of approximately 3,650 Ksh. A relatively small number of people with very high incomes in this group skew the distribution so that the mean is higher than the median. Smallholders can be diseggregated into three groups according to relative welfare criteria:

1. The lowest 40% have annual incomes valued at less than 2,000Ksh., ($260) and are largely subsistance producers with little capacity for investing time or money in risky innovations. Individuals in this group may live either in marginal agricultural areas, or on very small farms in high density, high potential areas, or as tenants or squatters on farms owned by others. Most of them cook inside small huts using traditional three-stone fires rather than jikos (small, round, metal, charcoal-burning cook-stoves) or kerosene burners, often because they lack the cash necessary to buy stoves or cooking fuel (but also because some simply prefer to cook with wood instead of charcoal). This segment of the population has least access to government services such as agricultural extension, schools, and dispensaries. They fetch water by hand, often from distances greater than one mile, and very seldom can afford water tanks or the iron sheet roofs necessary for rainwater catchment systems. They use very simple agricultural tools -- often only a panga (machete) -- and are able to afford neither to buy nor to rent bull or ox-carts or simple animal traction equipment. Those living in areas of lower agricultural potential tend to have relatively larger livestock herds (only local breeds) than those of comparable wealth occupying higher potential lands, who often keep only one cow and a few sheep and goats.

The highest priority energy needs of this group would include improved access to clean water for home consumption, more efficient ways of cooking with fuelwood, and easier access to fuelwood supplies. Projects aiming to benefit this portion of the population must entail very little risk to subsistence needs and must be very low cost (requiring a cash outlay of perhaps no more than about 5 or 10 shillings per household).

2. Those in the next 40% of the population have annual incomes valued at between 2,000 and 5,999 Ksh. Individuals in this group have a slightly greater capacity than those in the bottom 40% to invest some time or money in agricultural and other innovations. Some of them (perhaps 25-45%) can afford to cook with a jiko rather than three-stone fire and perhaps a slightly smaller percentage use water tanks to catch rainwater from iron-sheet roofs for domestic consumption. Only a very small number, however, have access to dependable year-round water supplies within a quarter to half mile from their homes. They have more contact than the bottom 40% with agricultural extension agents and other government services. Persons

management of all program and project grants or loans awarded under the Fund. MOE technical experts or advisors will meet with each organization receiving a program grant or loan and to the extent possible each receiving a project grant or loan in order to provide technical assistance at or near the start of the program or project. MOE also will provide all grantees with standard quarterly and annual cost, schedule, and technical reporting forms. Reports for all grants will be reviewed as part of the annual Renewable Energy Development Project reviews and as part of the AID Mid-Term Project Evaluation.

MOE will establish suitable accounting procedures for disbursing funds and assuring that funds are properly spent.

MOE will conduct a simple financial, technical, and management audit at least once during each program or project, on or before the eighteenth month from grant award or completion of the program or project, whichever is earlier. For local demonstration/extention projects, participation of District or Division Rural Development Fund (RDF) administrator or other designated DDC representative will be solicited and encouraged.

MOE will provide for closing out all grants at the end of the program or project, including receipt of the final report, final invoicing and reconciliation, and MOE final program/project evaluation. Ten percent of the RDF amount for any grant will be held back and disbursed only upon receipt of a suitable final report and of all necessary financial records.

Within the framework provided above, administration of the Fund should be kept as simple as possible. The application review process should provide for speedy approval at each level. Financial and administrative reporting and other requirements should be kept simple and appropriate to the small size of each loan/grant, due to the desire to involve local groups who may be better at local innovation and extension than they are at filling out forms, and the intent of using the loans or grants to accomplish tangible results rather than to create paperwork. Two useful models in this respect are the Rural Development Fund and CIDA's "Mission-Administered Funds" Program.

It is important to recognize the distinction between national energy needs and priorities, and actual short-term development priorities motivating rural people. Since project activities compete with other tasks for the rural poor's very scarce labor and cash resources, the actual priorities motivating allocation of these resources by the poor must be taken into account.

At present the two highest development priorities of most of the rural poor are expansion of educational facilities and improved access to water supplies. These are the areas in which locally initiated and organized development projects (Harambee or self-help projects) are most common. It is more difficult to motivate people to work on projects with longer term or less immediately recognized benefits such as forest conservation or substitution of water powered pumps for diesel pumps. While the need for forest conservation and substitution of renewable for nonrenewable (e.g., petroleum) energy resources is recognized at the national level, it is a need which is difficult to translate into action at the local level. Improvements in cooking technologies, for example, are often perceived to be a low development priority because of the low status culturally ascribed to tasks traditionally done by women. In this case, therefore, the project must focus on very low cost improvements in cooking techniques which can be developed and disseminated by existing women's institutions and organizations.

C. Time Allocation

With most families dependent on their own labor for all production and maintenance activities, little time is available for activities not directly related to the basics of day to day survival.

Because women perform the bulk of family agricultural as well as domestic activities in Kenya, most of them are simply unable to donate more than a few hours (possibly 2-5) per week to development projects. They are unlikely to devote their time to projects that do not address what they regard as their most immediate needs. In the high potential, densely settled areas of the country, there are generally two growing seasons per year and thus very little slack time in the agricultural cycle. Men in such areas generally concentrate on livestock and cash crops and perform almost no domestic maintenance activities such as fetching firewood or water or cooking. In western Kenya, a very large proportion of adult males migrate to Nairobi and other urban areas to work. They return home for only a few days every few months or so. This further increases the labor burden on women, who are usually left at home to operate the farm.

In short, time is very scarce in most rural areas particularly for women, who perform the bulk of domestic and agricultural labor. Because fetching water and fuelwood can often consume 50% or more of women's time, enormous welfare benefits can result from any contributions this project makes to reducing the amount of time required for these activities.

D. Reaching the Poor: Institutions, Extension, and Communication

This project will use a number of government and nongovernment organizations to promote and spread renewable energy applications in rural areas. It is individuals (particularly men) in the better off 20-50% of the population who have most contact with existing extension organizations. Lack of transport and personnel limits extension contact with less well off segments of the population, who often live in remote and inaccessible areas and who also may have little interest in extension services. Among government extension services in Kenya, those with best potential for assisting the project are probably the Department of Home Economics in the Ministry of Agriculture and the regular extension service of the Ministry of Agriculture.

In addition to government ministries, local representatives of the central administration such as chiefs and subchiefs can play a role in publicizing and disseminating information concerning new energy technologies or projects. In fact, acquiring the public support of local chiefs and subchiefs is in Kenya often an essential means of gaining acceptance for any new project. These local representatives of the central administration have in many heavily populated regions of the country completely eclipsed traditional leaders as sources of authority on many matters. Chiefs and subchiefs have access to an immediate and effective channel of communication with rural peoples in the form of barazas, or public, local meetings of residents of a particular administrative location or sublocation. Barazas could be used to awaken interest in energy related activities such as tree planting and cookstove experimentation among local voluntary organizations such as village women's groups and church groups.

District, divisional and locational development committees, headed by D.C.'s, D.O.'s, and chiefs, respectively, can also play a role. These committees would be useful for publicity, coordination and demonstration purposes, since their membership includes representatives of all government ministries operating at the relevant administrative level, as well as local educational, religious, and political leaders. Decisions concerning project site selection should not be left to such committees, however, since their concern with regional equity and their lack of technical expertise can lead them to place some projects in unsuitable areas for political reasons.

Various types of nongovernmental organizations and community-based local groups are expected to be used in the project. One of the most widespread and effective forms of community-based development in Kenya is Harambee self-help projects. These locally initiated and organized development projects are found in virtually all parts of the country and include such activities as building schools, hospitals, dispensaries, roads, cattle dips, and irrigation and water supply systems. Most Harambee projects involve building schools, both because education is the first development priority in most rural areas and also because local organization of more complex activities, such as water supply systems, is often limited by lack of technical expertise. Even after a local Harambee group

collects sufficient funds to begin a water project, it must often wait months or years for Ministry of Water Development surveying and engineering assistance required to actually begin a project because of a shortage of technicians. Nevertheless, Harambee projects offer the most active and widespread avenue for a variety of village level development projects. As discussed later, both the community tree planting and water development components of the project could effectively make use of Harambee groups. It must be emphasized, however, that local initiation and organization is the strength of Harambee development efforts and that too much external assistance can be the death blow to Harambee efforts. A.I.D. assistance to Harambee projects should therefore be limited to those which have already been successfully started. It should be in the form of small amounts of financial and/or technical assistance required to sustain already viable projects.

A variety of nongovernment organizations which could be used to initiate energy projects or to disseminate information exist in Kenya. (These are listed and described in more detail elsewhere in the report.) Some of them, such as the National Council of Women of Kenya and Maendeleo ya Wanawake, are based in Nairobi and have relatively little representation in rural areas. They do, however, perform important coordination and publicity functions.

Other nongovernment organizations, particularly church organizations have specific areas of geographic concentration where they have fairly strong rural representation. Church organizations represent a significant arena of local and national political competition and this sometimes makes practical cooperation among churches difficult to achieve particularly for water projects. Church groups might, however, be used effectively to help foster innovation in mud and clay cookstove technology. These groups operate on a small scale at the village level, but their activities can be coordinated through district and division level offices of the appropriate church. Such groups could be useful as a source of communal or cooperative labor, even in areas where traditional forms of communal work have largely died out.

E. Spread Effects

To the extent that AID is able to set up replicable mechanisms for energy technology experimentation, demonstration, and diffusion, the project will have spread effects beyond the initial groups involved in these activities. Success will require direct participation by local people in developing both techniques and diffusion mechanisms. Such direct participation will increase the likelihood of both individual project success and of spread effects extending benefits beyond the initial groups involved.

Tree planting efforts, for example, must be based on local knowledge about tree species suited to the area and should reflect tree use priorities in the existing social and economic system. Since the demand for trees in many rural areas exceeds the available supply of seedlings, achievement of spread effects

among individual farmers will not be difficult in such areas if local tree nurseries are expanded and adequate seedling distribution mechanisms are established. With the assistance of the agricultural extension service and local barazas, information on means of acquiring seedlings and the benefits of increased tree planting on individual farms can to a large degree spread by word of mouth.

In the case of community wood lots, on the other hand, spread effects are more difficult to achieve because such efforts depend on creating new motivations and modes of organization in rural communities. Spread effects in this case will depend on strong local leadership and good publicity.

Achievement of spread effects will also require that the various technology options are evaluated and tested in the actual rural contexts where their dissemination is proposed. It is quite evident that in Kenya there is little diffusion of certain "appropriate village technologies" beyond demonstration centers. This is due at least in part to social and economic disadvantages of the technologies being demonstrated. Both socio-cultural feasibility and spread effects can be enhanced if socioeconomic considerations are an integral part of this project's technical experimentation and analysis.

The need for keeping complexity and costs of new energy technologies low in order to reach the rural poor has been discussed elsewhere and is also essential to the achievement of spread effects. If the low cost, low complexity criteria are met, diffusion of new energy technologies in this project will then depend on making effective use of the full range of existing organizations and institutions discussed earlier. Many organizational and institutional means of promoting new technologies already exist in Kenya. Because the range of technologies considered in this project is so wide, effective diffusion will require a great deal of coordination of activities of the various organizations involved. Once benefits are demonstrated to and by existing organizations, however, diffusion activities should become self-sustaining efforts within the normal range of activities of such organizations.

It is likely to be individuals in the second 40% and not the poorest 40% of the population who have greatest access to and interest in existing extension, church and other organizations and institutions. If, however, successful and appropriate technologies are developed for diffusion by such groups, it is likely other individuals not directly involved would eventually learn of them by word of mouth and observation.

II. SOCIAL SOUNDNESS OF TECHNOLOGY OPTIONS

Forestry

Long term benefits of the forestry component of the project include: (1) a reduction in deterioration and erosion of agricultural land, which will help to alleviate further reductions in food and cash crop production potential; (2) a decrease in family labor required for gathering firewood, which increases time available for more productive activities such as agriculture, and may improve family food supply and income; (3) a slowing of increases in family fuelwood and charcoal cash expenditures allowing the purchase of food and other household essentials; and (4) an improved health and working capacity resulting from a reduction in both the physically difficult burden of travelling long distances to fetch firewood and in the necessity to cope with fuelwood shortages by cutting back on the amount of food or number of meals cooked per day. Shorter term benefits include: (1) generating individual employment opportunities for local people in extension, nursery, and tree planting activities; and (2) assisting ministries, training institutions and certain nongovernment organizations involved in forestry by providing training and other types of support. Since about 85% of the wood consumed in tropical Africa is for domestic household use, and since most rural households depend on wood for cooking, a project focus on wood fuel production can directly affect AID's poor majority target group. Field visits have indicated that the demand for seedlings in rural areas is quite high and that there is an acute shortage of seedlings available for planting. Seedling production and distribution is thus an important focus of the project.

Increasing wood production in high rainfall agricultural lands is, as suggested above, essential both to the well-being of individuals living in such areas and to the nation's wood supply-demand balance. To help achieve that goal, the project involves tree-planting at both the community and individual levels. Community tree planting is limited by land availability and will depend upon effective cooperation with local County Councils, since it is they who control the remaining "communal" or public land in areas where land has been adjudicated and individually registered. Labor for communal tree planting could be either in the form of "casual" laborers hired for a few days, or free, communal labor donated by residents. For the latter to succeed it would require the cooperation of local administrative officials such as chiefs and subchiefs to explain to area residents the long-term benefits and necessity of tree planting and to organize a system by which many individuals devote possibly a few hours a month to a tree planting and care.

One problem involved in the communal approach is that it requires establishing and explaining how benefits are to be distributed among community members who donate their labor to the effort. It should be remembered that in high potential agricultural areas of Kenya, introducing community or village wood lots means recreating what is largely a no longer operating form of community organization and cooperation since land and other economic resources in such areas are

now indivudallly rather than communally owned and utilized. It should also be recognized that it is likely rules concerning the distribution of wood benefits fall beyond the control of project personnel and are dependent instead upon the honesty and good will of local leaders (e.g., County Councilors) controlling the land used for tree planting. A third problem associated with use of communal lands for tree planting is that they tend to be the poorer quality lands in any given area and thus careful species selection is required to increase tree survival rates on such lands. A fourth important consideration with respect to such communal lands is that poorer residents in the area may depend on them to meet essential needs such as cultivation or livestock grazing. The current use patterns of any potential community wood lots must be examined before proceeding with tree planting so that the latter does not conflict with the needs of individuals dependent on the land for other purposes. If properly studied in advance, it is possible for tree planting programs to be designed which can improve the grazing or cultivation potential of the land in accordance with existing use patterns. In any case, land tenure and land use patterns must be well understood before undertaking a tree planting program, since rights to tree products often differ from rights to food crops or nonpermanent crops. Tenant farmers, for example, occupy land for varying periods of time and are unlikely to care much about tree planting if they do not believe they will be able to reap the benefits themselves.

It is possible that in medium potential areas where land is not yet adjudicated, on the other hand, community wood lots might be more successful than in high potential, adjudicated areas. In both types of areas community wood lots may be more likely to be successful if multi-purpose trees are planted which yield other products such as fruit and fodder, as well as fuelwood. Resolving problems of communally distributing benefits and costs may be easier in medium potential areas where communal forms of organization have not yet disappeared, as they have tended to do in higher potential areas.

Community fuelwood programs entail a number of organizational, administrative, and motivation problems discussed above. In Kenya community fuelwood programs would probably be most likely to succeed if organized and initiated locally as Harambee projects, instead of being imposed from above by the government. AID could offer to provide seedlings to any such group wishing to begin a community tree planting project.

In addition to community or village wood lots, the project will also include a significant agroforestry component to encourage individual farmers to plant more trees on their farms. This can provide a variety of benefits such as fodder for livestock, food for consumption or sale, building and fence poles, improved soil fertility and nutrient levels, and soil conservation. All of these features are likely to make tree growing attractive to many small-scale farmers. Trees can improve a farmers' welfare by increasing the productive potential of his land and helping to meet his subsistence and consumption needs, as well as possibly providing new cash earning opportunities. Given existing patterns of small scale farming in Kenya, tree planting along boundaries and scattered throughout various plots on a farm are likely to meet with much more success than attempts to get farmers to grow concentrated plantations or groves of trees. Farm sizes are simply too small to favor tree plantations since there are too many competing uses (e.g., growing of essential food crops).

Among large-scale farmers, on the other hand, planting trees on concentrated plots of an acre or more would be more likely to succeed, since such farmers can afford to set aside agricultural land for trees. While such farmers do not fall within AID's poor majority target group, they should not be ignored in the tree planting component of the project since it is they who are most likely to have land available for tree planting. In fact, the project will investigate and promote incentives to encourage private, large-scale land owners to plant trees, as well as to encourage County Councils to plant trees on public trust lands.

Tree species most likely to be quickly adopted by farmers are those with the most immediate and diverse range of benefits. Benefits must be clearly perceived by the farmer if he is to devote some of his scarce labor time to such tasks as planting, weeding, pruning, and harvesting trees. These tasks will compete with other essential agricultural tasks, and trees which fit in well with the farming system and agricultural cycle will be more successful than specialized trees with very limited uses requiring a great deal of labor during periods of peak labor for existing crops in the local farming system.

Another issue requiring consideration is the question of ownership, sale and use rights within the family of different types of trees. In many parts of Kenya, men and women are each responsible for certain specific crops and trees and not others. Thus efforts to introduce tree planting on small farms must be done with an understanding of culturally defined sex roles and division of labor so that extension efforts can be directed to the appropriate family member and so it is clear at the start who will benefit from a particular program.

Before establishing seedlings in a nursery, basic preliminary research should be done concerning existing tree species and uses in the area. There is a tendency for forestry projects to involve widespread planting of exotic species, whereas planting of indigenous species can in some cases better meet the needs of the population with respect to factors such as end use and time required for maturity. Local people have extensive knowledge of tree species and uses and this should be used by project foresters.

Cooking Technologies

Four categories of fuel-conserving cooking technologies are considered: (1) improved three-stone fire; (2) improved wood stove; (3) improved charcoal stoves; and (4) biogas. As discussed earlier, improvements in traditional three-stone fires and wood stoves are most likely to benefit the poorest 40% of the population; improved charcoal stoves would not benefit the poorest 40%, but could benefit a large portion of the rest of the population (with the exception of the wealthiest 10-15%) and biogas could benefit only the wealthiest 5-10% of the rural population.

Most of the rural poor in Kenya cook inside a small hut using traditional three-stone wood fires. Better off families who can afford the initial purchase and charcoal fuel costs tend to use a jiko, though some of these prefer the taste of food cooked over a wood fire. Kerosene stoves and gas cookers are preferred by the wealthiest 15-20% of the population and are considered important symbols of status and upward mobility. Cooking tends to be done in very large quantities in large metal (or occasionally clay) pots. Many staple foods such as maize and beans require long hours of boiling since they are usually harvested and cooked after becoming hard and dry.

Fuel-conserving improvements in cooking techniques would produce national level benefits by reducing wood consumption. Such improvements would also produce individual labor and cash saving benefits for the rural poor. Improvements reducing fuelwood collection and charcoal production requirements at the household level benefit the poor (particularly women) by increasing labor time available for more productive (e.g., agricultural) activities. This can lead indirectly to improved welfare and increases in income. More energy efficient cooking techniques also produce immediate cash benefits to those who rely on purchased fuelwood and charcoal supplies, by reducing wood and charcoal expenditure requirements. Reductions in cash required for cooking fuels can produce nutritional and general welfare benefits by increasing the amount of money available for purchasing food and other household essentials (though of course it cannot be assumed such money would necessarily be spent in this way).

A. Improvements in Traditional Three-Stone Fire Cooking

Given the nearly nonexistent cash resources of the poorest 40% of the population, improvements in wood cooking techniques most likely to benefit this group involve very simple modifications of the traditional, unenclosed three-stone fire. This simplest level of improvement receives little attention from most institutions and organizations promoting energy saving improvements in cooking techniques. The Women's Division in the Ministry of Culture and Social Services and the Home Economics Department in the Ministry of Agriculture have, however, been involved in such innovations to some degree.

For cultural reasons, improvements in cooking technologies are likely to be a very low expenditure priority in most households, since cooking and collection of fuelwood tend to be regarded as unimportant, low status tasks, and males tend to control cash. In any case, such innovations could probably require cash outlays of no more than about Ksh. 5-10 per family among the poorest 40% of the population. Wide diffusion of new technology among this

segment of the population must also require very simple construction and maintenance procedures, since this group has very little access to existing extension services and institutions.

The simplest improvements in three-stone fire cooking techniques reducing fuelwood consumption would benefit rural households by reducing firewood collection time and increasing labor time available for more productive activities. For those homes which purchase firewood, the benefit would be a reduction of cash expenditure requirements and probably increased food consumption resulting in better nutrition.

Current social benefits of traditional three-stone fire cooking which must be taken into account in project design include provision of light, warmth for space heating, a social gathering point, wood preservative, and animal, insect and pest protection. Simple, low-risk, low-cost improvements in three-stone cooking which do not seriously alter wood fire benefits listed above might be feasible.

A horseshoe shaped mud or brick wall enclosing the fire might be acceptable if the wall were not more than a few inches high. A higher wall with greater heat efficiency might conflict with social uses of an open fire. The same would hold true of another possible improvement of the three-stone fire involving surrounding the fire with a reflective surface such as aluminum sheets. Other means of improving fuelwood efficiency in traditional three-stone cooking, such as drying wood before burning, are often not possible because of severe labor and transport constraints the rural poor face.

Combining hot box or fireless cookers with the three-stone fire is an innovation which might succeed in some areas if the cooker could be made from inexpensive and locally available materials. Since many traditional foods require long hours of boiling, rather than simmering, it is possible this innovation would meet with resistance. However, additional research is needed to establish the suitability of hot boxes for cooking traditional Kenyan foods. They may be more suitable to warming already cooked foods than to cooking mixtures requiring long hours of boiling.

Solar warmers are likely to encounter similar problems of adaptation to existing cooking practices. In Senegal they were found to be unacceptable because they significantly lengthened required cooking times (in some cases by a factor of 4 or 5).

B. Mud and Clay Wood-Burning Stoves

Although various groups such as Village Technology Units, the Home Economics Department and others have attempted to introduce them, mud and clay stoves have as yet met with very limited success in Kenya. They are found primarily in demonstration units and in a few individual homes. Field visits to such homes indicated that improved stoves continued to be used in conjunction with jikos and kerosene burners. It is not clear whether lack of information or disadvantages of existing stove models themselves is the major cause of their

limited diffusion to date in Kenya. Careful assessment of user acceptability (durability, economic and social feasibility) is required for the various stove models being demonstrated in training institutions in Kenya. This project will therefore focus on both testing and experimentation in stove design and on extension and training to disseminate promising stove models.

Factors which may limit their acceptability include height (some require an unfamiliar standing posture); cost in labor and cash required to construct them; and availability and durability of materials used (some, especially mud and clay mixtures, require frequent -- often weekly -- patching of cracks). Soil types and hence appropriate stove construction mixtures (soil, sand, dung, etc.) vary greatly by region; hence, stoves requiring very little modification of existing house construction mixtures in an area are more likely to be successful than stoves requiring costly importing of exotic clays, etc., or those requiring technical or extension assistance in determining correct clay/sand/dung mixtures. The most durable models require cement, bricks, or some sophisticated firing -- all of which often surpass the cash, material and technical capacities of rural areas. Those who can afford bricks or cement are also likely to be able to afford more socially prestigious cooking techniques such as jikos, kerosene burners, or perhaps gas cookers. Thus there is a problem of motivating people to adopt possibly more fuel-efficient stoves whose materials and appearance may cause them to be regarded as a step backward. A tradition of pottery making exists in western Kenya, for example, but it is considered increasingly nonprestigious, and skill and interest in pottery are dying in many areas. Nevertheless, since the technical skills are there, it would be worthwile to include some experimental components in the project dealing with design and testing of pottery stoves.

High mass mud or clay stoves are somewhat effective heat radiators, but the practice of leaving stove doors open to increase space heating effects virtually cancels the potential fuelwood savings arguing for use of such a stove in the first place. Incorporation of a smoke release passageway, though it has decided health benefits, competes with traditionally recognized benefits of smoke mentioned earlier. Thus available data suggest that some of the design criteria of improved stoves conflict with certain benefits (e.g., space heating, smoke) of traditional fires. On the other hand, as fuelwood becomes scarcer and purchase and collection costs increase, stoves with significantly lower fuel requirements may become a higher priority in rural areas and adoption rates may increase.

C. Improved Charcoal Stoves

Costs of purchasing the stove and fuel make charcoal stoves inaffordable for most of the poorest 50 to 60% of the population. At the same time, the sector which can afford jikos may not be willing to sacrifice scarce cash at hand to pay the higher purchase price of an improved jiko in order to realize longer term benefits of reduced operating costs. In many cases, those who have more cash on hand would be more interested in buying a kerosene burner for status reasons rather than a better jiko. Charcoal is, however, the preferred cooking technique for many in that segment of the rural poor who depend

on purchased cooking fuels. It is more convenient to use and easier to transport than wood. The thermal efficiency of metal charcoal stoves is about 15%, or twice as high as the traditional wood fire. In comparison to mud and clay stoves, metal charcoal stoves have the advantages of durability, easy portability, small size, low maintenance requirements and effective space heating qualities. Scrap metal cooking technologies already exist in Kenya and because jiko makers are more centrally located (though mostly in the informal sector), it would be easier to disseminate new metal stove designs than it would be to disseminate improved mud or clay stoves.

Principal benefits of improved charcoal stoves would include reductions in cooking time (benefiting women) and reductions in fuel purchase costs, which would make more cash available for other household needs.

As with mud and clay stoves, however, further experimentation with jikos is required to produce a design that is socially acceptable and economically viable. Some of the new jiko designs in Kenya are said to be too slow, too heavy, too bulky, and too expensive for most people to be willing or able to pay the initial purchase prices. In addition, they take longer to build and are therefore less attractive to manufacturers. An artisan can make about 6 traditional jikos per day but only one improved jiko. This increase in labor time required tends to encourage price increases beyond material costs. Price increases tend to put new jikos beyond the reach of many potential users even though the fuel savings would make them pay for themselves in a short time.

The more elaborate versions of improved jikos, incorporating such features as water heaters and ovens demonstrate the versatility and possible future potential of jikos, but these would benefit only a small minority of the population, whose cash resources and cooking needs far exceed the current norm.

C. Biogas

Biogas production techniques at the individual farm level will not be included in this project because costs of these systems far exceed the capacity of all but a small minority of the rural population. Biogas units cost more than Ksh. 4,000 excluding transportation, and require five to twenty cows to operate. Even in many cash crop growing areas, average small-scale farmers can afford to keep no more than one or two cows. In addition, biogas systems require huge quantities of water (a minimum of 40 litres per day), which only those who happen to live near piped water supplies or who can afford to hire labor to transport water could manage.

Field visits to existing farm level biogas units indicated that most were not working or were working far below their potential capacity, and that even for those who can afford them, the systems entail serious problems which reduce their attractiveness. One of these is that people find frequent handling and transporting of cow dung distasteful work. Another is that the currently used biogas cooker leaks, is highly inefficient, and cooks too slowly due to poor heat regulation and low heat volume. At the sites visited, biogas cooking tended to be used only for the fastest, lightest foods such as milk and tea, while fires

and jikos were still used for the bulk of the family cooking. Simple improvements could be made in the cooker itself but these would increase the cost beyond the present Ksh. 250

In addition to cooking, biogas units produce a slurry which is very effective as fertilizer. However, it is the novelty of the cooking gas itself and not fertilizer which at present attracts wealthier people to biogas units. Use of the slurry as fertilizer is an important benefit which deserves further attention. It might be useful, in particular, to compare the economics of production, distribution and use of current chemical fertilizers and biogas slurry.

Biogas applications above the individual farm level may be more promising in the short run. Such units might benefit institutions with large numbers of confined animals by providing cooking energy, waste management, fertilizer and other benefits discussed in the technical analysis. Publicized institutional use of biogas could produce some spread effects to other institutions and individuals.

Charcoal Production

An estimated 70% of Kenya's charcoal is used in urban areas, with about 45% of it used in Nairobi. Most of it is produced in rural areas using traditional earth kilns in which an estimated 75% of the wood's energy is lost in the conversion process. For the rural poor, however, intermittent charcoal production is often an essential source of income. Poor small scale farmers, for example, may practice occasional charcoal production during periods of food shortage or in nonpeak labor periods in the agricultural cycle. A traditional kiln produces an average of about 8-10 bags, each of which can be sold for about Ksh. 15-20 to a transporter (usually a passing lorry) near the producer, or for KSh. 20, and up in towns if the producer himself can transport it. Using traditional production techniques, no cash outlay is required, as kilns are constructed entirely from available soil and plant materials. However, yields are extremely low -- often only 8-10% recovery weight.

Any yield-increasing improvements in traditional charcoal making techniques would ideally benefit poor producers in both high and medium to low potential lands by increasing their cash incomes. Since many such producers live in the more marginal medium and low potential agricultural areas (often without a good cash crop), charcoal earnings can represent a significant portion of their cash incomes.

Demonstrating improvements in traditional charcoal production techniques to informal sector producers is extremely difficult, since many of these are "illegal" producers and many live in areas difficult to reach through existing extension mechanisms. Moreover, producers operating near the subsistence level have a limited capacity for experimenting with new techniques. There are, however, certain simple improvements which lie within the range of some traditional producers. Simply using dried wood, uniform sized pieces of wood, packing wood more tightly, covering the kilns with a sufficiently thick layer of earth, or adding insulation barriers (e.g., tin containers locally termed "debes") between soil layers can as much as double yields in some cases. Although insulation slows burning, labor requirements in the removal process can be decreased when debes are used as insulation in a traditional kiln. Cutting

wood in uniform sized pieces to reduce losses through complete burning of smaller wood pieces may require more tools than many small-scale producers own; most of the poor own only a panga, while a pruning saw or an axe costing about Ksh. 30 is required for more effective wood cutting.

Small-scale producers to whom information regarding improved techniques would be more easily disseminated are those who obtain permits from the Forestry Department to cut trees in specified forest areas. Some of these individuals can afford better tools such as axes, or occasionally cross-saws or chainsaws. Improved methods could be publicized to these producers, for example, via the Forestry Department or Ministry of Agriculture extension officials, though the former currently lack the necessary extension personnel.

Improved charcoal production techniques involving portable metal kilns or semi-portable brick and masonry kilns would bypass the small producers and would reach instead larger scale producers, who often produce charcoal as a byproduct of such industrial operations as East African Tanning Extract, Ltd. (see Technical Analysis). Before investing heavily in large scale, capital intensive charcoal production methods, it is necessary to evaluate more fully the degree to which this might significantly reduce income among small-scale traditional producers, who might be eliminated from production. Portable and semi-portable kilns require a considerable cash outlay for purchase, as well as high cost of transporting wood. Both of these factors place such kilns beyond the means of traditional small-scale producers.

Finally, though rising rates of charcoal consumption involve short-term benefits for rural charcoal producers in the form of increased income, there are negative consequences in the long term, as rural wood supplies are depleted and the poor have to travel longer distances and spend more time and money on firewood to meet their own needs.

Water Technologies

Improved water supply is one of the top energy priorities of the poor. At least 4 million people in Kenya walk more than a mile in the dry season to get drinking water. According to a study of 10 districts in Kenya by Whiting and Krystall, women spend up to 6 3/4 hours per day fetching water. In five of the ten districts included in the Whiting and Krystall study, the average time spent collecting water was five or more hours per day. Per capita water consumption levels were found to be quite low, exceeding 10 litres per capita per day only in Central Province and in special water schemes.

Fetching water for domestic use from natural sources is done almost exclusively by women in most parts of Kenya. Since women tend to be responsible for a number of other domestic and agricultural tasks, reducing time required to collect water could significantly increase labor time available for more productive activities and could thereby indirectly produce increases in rural incomes and improve general welfare. Rural water supply systems can increase per capita water consumption levels and thus improve hygiene and produce health benefits for rural families.

Water supply projects are a very high priority in rural Kenya. An estimated 100 new Harambee water projects are begun each year. However, problems of scale, inadequate organization, and poor technical capabilities have limited the number of successful, locally based and initiated rural water supply projects. These problems have also reduced the effectiveness of water systems once established; more than half of these are unreliable due to inadequate design, construction and maintenance.

Because availability of technical skills, capital and labor is very limited in rural areas, rural water supply projects must be very simple, cheap and easy to maintain in order to be successful once external project personnel depart. It may be best over the long term to avoid projects requiring frequent and somewhat complex technical assistance in maintenance, given the quite often very thin coverage by both private and government technicians in rural areas.

Because water projects are such a high priority in rural areas, privately organized community level projects (e.g., Harambee projects) can sometimes obtain cash contributions of up to $25 per family. Families too poor to pay this often borrow the money from friends and relatives. The only other type of development projects which can get contributions this large is schools, which are the first development priority in most rural areas. With respect to Harambee water projects, AID could play a role in stimulating them but the real strength of such projects is that they are organized and initiated at the local level.

A. Windpumps

According to currently available wind data, areas of heaviest population in Kenya's high potential wind belt include regions around Mombasa, Malindi, Eldoret, and Kisumu. Much of the high potential wind belt otherwise covers only very sparsely populated and largely nomadic sections of the country. Available data suggest that with the exception of heavily settled areas listed above and a few areas of large-scale farming, wind power has limited potential for community water supply systems in Kenya. Moreover, even within the regions identified above, additional information is needed concerning water table levels and actual wind speeds and consistency before the potential of windpower in Kenya can be adequately assessed. Areas of windpump suitability are also limited by the requirement that windpumps must operate against a fairly low head, which means they may not be suitable in highland areas, where most of the population is concentrated. If the water level is no more than 30 feet, a windpump could serve as many as two or three thousand people. One problem that must be dealt with, however, is that wind pumping capacity is likely to exceed distribution capacity. Diesel pumps often must operate only six to eight hours per day to produce a sufficient community water supply. Windpumps operating continuously might require greater storage capacity and possibly a mechanism for distribution or selling surplus water produced by a given pump.

As discussed in the technical analysis section, there have already been many windpump projects and activities in Kenya. Some of these have been completely unsuccessful due to problems with maintenance and repair and incompatible patterns of social organization. At the same time, notable successes in windpower

appear to be confined to projects undertaken with external funding at religious missions or individually by an occasional (usually expatriate) large-scale farmer.

Since windmills have been in Kenya for several decades and have not yet generated striking interest by the government, very brief studies of the reasons for this are a necessary precedent to any large attempts to introduce still more windpump projects. A few demonstration projects might be warranted if, for example, such studies indicate an unawareness on the part of policy makers of potential uses of windpower substitutes for fossil fuels. A publicity campaign would probably be required to counteract the prevailing attitude that diesel pumps are a sign of "development", while windmills are "backward".

The complexity and very high costs of purchasing and installing windmills mean that their establishment would require substantial government financial and technical support. Windmills far exceed the financial and technical capabilities of many rural communities in Kenya.

B. Hydrams

Hydrams may be suitable for small-scale community water supply systems in areas such as the highlands, where much of the population is concentrated. A hydram can potentially supply about 120 families in an approximately three by four mile area. Because County Councils are turning from hydrams to diesel water pumps, second-hand hydrams are sometimes available for as little as about Ksh. 4,000 (US$ 560), though new ones may cost Ksh. 18,000 (US$ 2,500) or more. Second-hand hydrams are thus within financial reach of groups of families in wealthier cash crop growing areas. Families living in dispersed farms along a ridge (a settlement pattern typical of much of the central highlands, Kikuyu, Embu and Meru areas) have in some cases organized and contributed money to purchase and install a communal hydram, pipes and storage system to supply water for their own domestic use.

Field visits to existing hydrams indicate, however, that even the fairly simple maintenance involved (usually simply cleaning intakes) is a problem, as is replacement of stolen and worn out spare parts such as rubber washers and gaskets. Many of the hydrams visited had not been working for some time due to fairly simple maintenance problems prolonged by the unavailability of a plumber or water technician in the areas. Hydrams appeared most likely to work where a plumber was himself a member of the user group.

Thus existing evidence suggests that hydrams for small-scale community water projects entail maintenance problems which may be more serious than their financial constraints in some areas (though lack of finance is definitely a problem in many areas where they could be used). Communal hydrams also face some social and policial/organizational constraints since they require organization and pooling of resources by a group of neighbors. This type of community cooperation can be difficult to achieve in areas with strong competing political groups and without strong lineage or clan ties binding neighbors together. However, field visits indicated that hydram benefits are easily perceived by local communities and that strong local leadership and organizations can overcome such problems in some instances.

In sum, hydrams appear to have potential for expansion, perhaps primarily in better off tea and coffee growing areas of the highlands (where the terrain is sufficiently hilly for hydrams). Hydram projects face several village level social and political constraints, however, and seem to require a fairly special set of circumstances in order to succeed. If AID project technicians assist in establishing hydrams and training local technicians, this should increase the likelihood of long-term success of individual community projects.

A return to use of hydrams in government, as opposed to local communal projects, on the other hand, requires a change in preference away from single unit diesel systems which produce greater output at increasingly higher fuel costs.

C. Human and Animal Powered Pumps

Although handpumps are not common in Kenya, they have certain intrinsic advantages which suggest they deserve attention. These include relative simplicity, low cost, and ease of maintenance (at least in areas where the water level is high enough to use pumps with above ground access to the piston). A major disadvantage of handpumps, however, is their apparent lack of durability under conditions of heavy use in community water supply systems. Handpumps might be considered in areas of high population density where a relatively small number of families could pool their resources to purchase one for their own shared use. Local social and political organizational problems such as those discussed above with respect to hydrams would also be a factor in handpump systems.

Foot and animal powered pumps meeting low cost, low complexity and low maintenance criteria should also be considered as an option though they are not widely known in Kenya.

D. Water Power for Local Industry

Water power for electricity generation is outside the scope of this project since it does not address the most immediate needs of the rural poor. The government's emphasis on rural electrification is important, but its effects are largely limited at present to better off urban dwellers and very wealthy rural people who can afford permanent houses of stone rather than mud.

Water power for grain grinding mills will be considered in this project. These have been in Kenya most of this century but have since Independence increasingly been replaced by diesel powered grinding machines. Rising diesel fuel prices, however, mean that water powered options merit new attention. However, diesel grinding machines have the advantage of being faster and more conveniently locatable than water-powered mills, which must be at valley bottoms.

A project component intending to simulate a return to water powered grain mills might not produce significant immediate benefits for the rural poor. The latter do not own grist mills and it is unlikely any reductions

in grain grinding prices occurring with a shift to water mills would significantly affect their welfare. The poor would benefit somewhat, however, if grain grinding equipment were improved (e.g., by using a modern grinding mechanism with electric power) to reduce grinding time as well as cost, or if the number and distribution of mills were improved to enable easier and quicker access. Such improvements could reduce the labor burden on rural women.

Other water technologies such as solar pumps and solar desalination systems are still in the testing phase in Kenya and insufficient data exist to evaluate them. In addition, they are both extremely expensive.

ANNEX C. ECONOMIC ANALYSIS

I. SUMMARY

Kenya faces two major energy problems. First, with no proven hydrocarbon reserves and a comparatively large modern sector, Kenya is heavily dependent upon oil imports. The costs of such imports, together with rising costs of imports of manufactured goods and of borrowing in international markets, have contributed to large and increasing balance of payments deficits on current account. These deficits in turn increasingly will limit capital availability for domestic investment and thus constrain national economic growth. Second, consumption of wood for all purposes including use as a fuel appears to exceed forest replenishment rates by a wide and rapidly increasing margin. Continued deforestation has serious implications for deterioration of productivity of agricultural lands, premature silting of rivers and dams (which are major sources of water supply and energy), loss of wildlife habitat, and lessened retention of climatic moisture.

Kenya has limited options for dealing with these problems. It can expand its production of electricity from indigenous sources (hydro and geothermal) somewhat, although silt buildup in the Tana River may limit such potential. Prospects for substituting biomass-derived liquid fuels (e.g., power alcohol or liquids extracted from species such as jojoba or euphorbia) are limited by technical and economic uncertainties and more importantly by the urgent need to expand acreage devoted to foodstuffs and export crops. Solar and wind offer limited prospects for substitution for imported petroleum products before the year 2000. The area offering the greatest potential for reduction of oil imports, particularly in the short to medium term, is energy conservation.

For the immediate future, energy conservation policy is likely to focus primarily on means of increasing the efficiency of energy use in accomplishing a given activity (e.g., producing a ton of cement or driving a passenger one kilometer), with particular emphasis on measures which reduce consumption of light petroleum products such as motor gasoline. In the medium term, policy is likely to expand to encompass structural changes in industry, agriculture, transport, and services to take into account the permanently changed cost of energy relative to labor and, to a lesser extent, capital inputs. Such structural adjustments both complement and reflect the Government of Kenya's recent emphasis on labor-intensive industry and agriculture.

With respect to the imbalance between wood supply and demand, policy-making is clouded by the potential competition between energy and food production on scarce productive lands, uncertainties regarding individual or community willingness to either use firewood and charcoal more efficiently

or expand afforestation efforts, and a lack of clear definition of inter-ministerial roles. A period of research and experimentation and of gradual identification and expansion of successful afforestation and conservation efforts appears necessary before a broad program to right Kenya's wood supply-demand imbalance can be launched.

II. COMMERCIAL ENERGY

A. Oil Imports and Kenya's Economic Growth

Kenya consumed an estimated 1,677,500 tonnes of oil in 1979, which represented over 82% of its estimated primary commercial energy consumption. Kenya's net oil import bill (import costs less revenues from exports of petroleum products from the Mombasa refinery) totalled over K£ 68.9 million in 1979. This equaled over 22% of Kenya's total exports, excluding exports of petroleum products, and exceeded the value of Kenya's second largest export commodity, tea.

While Kenyan oil consumption increased just over 29% between 1975 and 1979 (or an average of 4.76% per year), Kenya's net oil import bill over this period increased by more than 75%. The increase would have been substantially greater had not the price of the Mombasa refinery's exports of heavy fuel oils increased at an even faster rate than did the price of crude oil, thus offsetting part of the rise in import costs. As it was, in 1979 alone, while oil consumption increased by only slightly more than 1%, Kenya's net oil import costs jumped by 46%.[1]

The continued escalation in oil prices, together with increases in the prices of imports of manufactured goods and developed countries' depressed demand for primary products (both due in part to the worldwide increase in oil prices), already has damaged Kenya's economy. GDP growth adjusted for inflation was only 3.1% in 1979, well below the average for the 1970's and below the estimated population growth rate. Kenya's terms of trade have declined 7.6% over this period

The impact of price increases and the sluggish international economy is recognized in "Sessional Paper Number 4 of 1980 on Economic Prospects and Policies." Balance of payments on current account for the Fourth National Development Plan period (1979/80-1982/3) were estimated at twice those forecast in the Plan (K£ 1,026 versus 511 million). The target average annual GNP growth rate was lowered from 6.3% to 5.4%. Since the Plan itself projected employment growth of only 3.8% at the former GNP growth rate of 6.3%, the revised GNP growth rate implies a drop in annual employment growth to well below the estimated 3.9% annual growth in population.

Moreover, due to cutbacks in the GOK's projected Recurrent and Development Budgets, the GOK now projects a decrease in per capita expenditure on social

1. Ministry of Economic Planning and Development, Central Bureau of Statistics, "Economic Survey 1980," June 1980.

services over the life of the Plan.

The Fiscal 1980/81 Budget assumes even lower growth targets than those above.

The pattern of threatened economic stagnation unfolding in Kenya is a common one in developed and developing countries. Rising oil import costs lead to an ever-larger balance of payments deficit on current account. At first, such deficits, may be financed through increased borrowing in international markets. However, as the limits of such expanded borrowing are reached, such deficits -- and the now-increased debt service costs to finance past deficits -- must be financed by reducing domestic consumption and savings. Typically, the burden has fallen inordinately on savings, reducing the amounts available for investment, which in turn reduces future economic growth. The effects of the drop are enlarged by the rapid worldwide price escalation in capital goods, which increases the amount of capital investment required to achieve each percent increase in GNP. Kenya is no exception.

The savings rate in Kenya has fallen from 20.6% in 1970-72 to 18.1% in 1976-79. At the same time, the incremental capital-output ratio (ICOR) has risen: while in 1970-72 it took an estimated K£ 3.24 to produce an increase in output of K£ 1, since 1976 an estimated K£ 4.35 has been required to produce the same K£ 1 increase in output.[1] Merely to illustrate the scope of the problem, a direct mathematical relationship (admittedly a gross oversimplification) would imply a more than one-third reduction in the annual GNP growth rate. In fact, the growth rate has dropped by more than one-third since 1973.

The projected 1980 balance of payments deficit on current account is expected to rise to K£ 212.1 million, or fully 72% of 1979 domestic savings. Even this estimate may be optimistic in view of the estimated roughly 60% increase (to K£ 110 million) in net oil import costs in 1980.

Some of the responses to this situation involve international or domestic economic, not domestic energy, policy. For example, the GOK recently has achieved notable success in negotiating increased concessional aid from OPEC members. In terms of domestic economic policy, the GOK is trying to develop policies to promote export-oriented and labor-intensive industry. On the negative side, the Government itself has been a major contributor to the decline in the domestic savings rate, by incurring substantial increased Recurrent Budget deficits and reducing the ratio of Development to Recurrent Budget Expenditures.

B. Scope for Reduction in Oil Import Costs

Besides economic and international negotiating initiatives, the Government of Kenya has begun to consider measures to attack the problem of oil imports directly, by substituting domestically available energy sources, by increasing the efficiency of energy conversion and end-use, and by encouraging gradual structural adjustments to less energy-intensive economic activities.

[1] Economic Survey 1980. It is likely that the present ICOR is substantially above the 1976-79 average.

Table C-1 presents a breakdown of oil use in Kenya in 1979 while Table C-2 show trends over the period 1970-77.

Unfortunately, no one has yet conducted a detailed assessment of where and how commerical energy is used within the Kenyan economy. The SUNY StonyBrook Institute for Energy Research conducted a survey of household energy use in Nairobi, stratified by household income level.

Thomas Tuschak, former UNDP energy advisor in Kenya, assisted in designing and carrying out a rural energy survey, which currently is in the process of being updated by Kenya's Central Bureau of Statistics. Finally, Professor Lee Schipper has been examining energy use in the modern industrial, commercial, and transport sectors. These examinations have been carried out at different times for different purposes, to a great extent by expatriates who have taken the raw data with them. A number of sectors, such as agriculture and the smaller-scale industrial and commercial/services sectors, have not been analyzed at all.

The only attempt to integrate what is currently known about energy use in Kenya into an overall energy supply-demand has been make by Professor Schipper (Table C-3). As Professor Schipper is quick to point out, the balance is incomplete, it is highly aggregate (deriving primarily from the information sources summarized in Tables C-1 and C-2), and some of the allocations involve little more than educated guesses.

Before intelligent energy policy and program recommendations can be developed, the Ministry of Energy will require more detailed information on energy use by sector. Such information must relate energy use, by type of fuel/energy source, to activity/output levels and to efficiency of energy conversion and end-use devices. The StonyBrook AL-EDIS energy assessment system developed by the State University of New York (SUNY) StonyBrook, to be installed and used as part of the Beijer Fuelwood Planning Project and supported longer-term as part of this Project, provides the system framework for such use analysis. However, because the AL-EDIS system is only as good as the data input, a number of energy survey or other data collection systems must be introduced.

Despite data limitations, some conclusion regarding opportunities to reduce oil imports can be drawn from existing information. First, aviation fuels currently constitute almost 22% of total consumption of petroleum products, and the proportion is growing. Most of this represents jet fuel used by the major international airlines serving Kenya; and it is they who make decisions regarding equipment selection, routing, where to take on fuel for other runs, etc. which determine energy use. At the same time, because of the importance of tourism to the Kenyan economy, the Government must be concerned that the airlines do all that is possible to conserve energy in order to limit what has been a steep rise in the price of passenger air travel to and from Kenya. Conversion to jumbo jets has

TABLE C-1

KENYA CONSUMPTION OF PETROLEUM PRODUCTS[1]

	000 tonnes 1979	of total 1979	annual change 1975-79	1978-79
TRANSPORT [2]	1025.8	65.4%		
Premium and regular petrol	302.0	19.3%	6.5%	3.9%
Arabian fuels	344.0	21.8%	4.5%	2.8%
Light diesel oil	349.2	22.3%	8.2%	7.7%
Heavy diesel oil	30.6	2.0%	-1.7%	5.5%
OTHER	542.1	34.6%		
LPG	20.2	1.3%	10.2%	16.8%
Kerosene	89.5	5.7%	12.6%	14.5%
Fuel oil	432.4	27.6%	2.1%	-6.8%
TOTAL	1567.9	100%	5.2%	2.0%

[1] "Economic Survey 1980," p. 129. Totals are before refinery usage

[2] Some use shown is not for transport. However, transport is the predominant user in each of these categories.

TABLE C-2 : DISTRIBUTION OF FINAL PETROLEUM PRODUCTS BY SECTOR, 1970-1977

	1970	1971	1972	1973	1974	1975	1976	1977
Road Transport	20.0	25.3	23.7	23.8	27.2	27.0	25.7	28.5
Rail Transport	22.7	22.4	16.3	8.0	7.4	7.2	5.5	6.0
Marine	16.3	10.6	15.2	14.5	15.8	10.3	5.7	8.8
Aviation	7.9	10.6	9.3	18.1	22.2	23.6	21.9	21.6
Sub Total Transport	66.9	69.6	64.5	64.4	72.6	68.1	58.8	64.9
Agriculture	6.0	6.2	5.2	5.1	4.6	4.7	3.9	4.2
Power Generation	7.9	8.3	9.6	8.9	7.6	7.5	11.6	8.3
Industry and Commerce	12.8	17.6	15.4	14.8	23.9	18.9	25.4	24.0
Other and Unallocated	6.3	-1.7	5.3	6.8	-8.7	0.8	0.3	1.4

SOURCE: SINGH (1978)

TABLE C -3

PRELIMINARY ENERGY SUPPLY DEMAND BALANCE

PRIMARY SUPPLIES	Quantity (10^6 EWA)		USES							
	Losses*	Net Available	Res.	Bldgs. Com.	Lg. Indus.	Auto	Truck, Bus	Rail	Air	Other
ELECTRICITY										
Hydro, Incl. Import) 1060)	200	1210	304	313	630**					
Thermal elec. 350)										
COAL 360										
OTHER (Bagasse) 700										
OIL										
Crude & Prod. 34500										
- exports										
stock 15800										
NET 18700	1200	17500								
Lighting, Cooking kerosene		750.								
LPG (bulk)			(—90	—)						
(cylinders)		(187)		(—97	—)					
MOTOR Spirit Reg.										
Prem.		3146				3146				
DIESEL FUEL Gasoil		5550				(1440	—)			
Heavy		350					(-571	—)		
JET FUELS, AV GAS		3442							3442	
HEAVY OILS		6120		(-5920	—)			1050		1450 EL.GE

1,200 GWh Oil + 40 GWh ELEC (both used in EAOR); Transmission Losses, Unaccounted from ELEC. Sectors; 1530 GWh Oil consumed to produce 350 GWh Thermal Electricity; 50 GWh Self Generation, 40 GWh to EAOR.

** INCLUDES SOME INDUSTRIAL USE

has reduced energy use per passenger-mile, and gradual introduction of airbusses and energy-efficient fanjet engines should result in further reduction in such energy use. At the same time, the prospect of stimulating airlines' use of Nairobi as an intermediate refueling point may provide some opportunity to increase petroleum product exports, if this could be done without worsening the Mombasa refinery's problems of imbalance in demand for light versus heavy petroleum products.

Road transport constitutes a high Kenyan priority for energy conservation and fuel-switching, particularly in the short-term. Although below the proportions of developed countries, road transport fuels (primarily petrol and diesel), still constitute a large and growing percentage of total petroleum products use, having increased from 20% in 1970 to close to 30% (or possibly even more) currently. While in 1979 growth in demand for premimum and regular petrol slowed considerably, petrol still itself accounts for close to 20% of total consumption. Morover, as a comparatively light product used in great quantities, it is petrol, more than any other product, which causes the problems of the Mombassa refiner's having to produce a surplus of heavy products (primarily residual fuel oil) in order to satisfy the demand for high and middle distillates.

Kenya currently has in Interministerial Transport Energy Conservation Committee, chaired by the Ministry of Energy, to recommend initiatives for reducing petrol use. Major options would appear to include conversion to diesel matatus (for which studies already have been completed), dieselization of the 50% or more of the total automobiles owned by fleets (Kenatco, Peugeot Car Service, etc.) and of light pickup trucks owned by fleets or by large industrial/commercialconcerns, and further changes in pricing and taxation policies to encourage purchasers of new private automobiles to purchase more energy-efficient cars or switch to diesel.

Recent Mombasa refinery yield statistics suggest that Kenyan petrol use may already have reached the no-growth stage and perhaps even be beginning to fall slightly. An aggressive conservation and fuel-switching program should be able to achieve a reduction in petrol use of at least an average 2% per year over the next several years.

The other major area of potential efficiency improvement is industry, which accounts for well over one-fifth of all petroleum product consumption. Experience in the U.S., OECD countries, and industrialized developing countries suggests that, with aggreseive energy conservation, energy efficiency improvements (that is, energy consumed per unit of output) of 20-30% are achievable within a five-year period without substantial new capital investment. Such savings are achieved through such "housekeeping" measures as plugging steam traps, improving boiler operating efficiencies, etc. There are a few examples of efficiency improvements of this magnitude having been achieved in Kenya. In general, however, Kenyan industry is only slowly feeling the economic incentive and acquiring the technical knowledge necessary before energy efficiency improvement will occur.

Reasonable energy efficiency improvement and fuel switching measures, concentrating on transport and industry, should be able to achieve within five years a 20% reduction from projected "business as usual" oil consumption levels. Thus, if Kenya achieves its revised Development Plan annual GNP growth target of 5.4% and "business as usual" means an oil consumption growth rate of 80% of this amount or 4.05%, 1985 petroleum products consumption would be 1,989,600 tonnes. The achievable savings potentially are 397,920 tonnes. At this savings level, the growth rate in petroleum products consumption would have been reduced essentially to zero.

In fact, the above calculations are likely to understate both the potential savings and what is likely to occur under" business as usual" conditions. Energy planners worldwide consistently have underestimated consumers' economic response to higher energy prices. The above estimates are based on very conservative response assumptions which are well below recent experiences. Thus, an absolute reduction in oil consumption -- and thus in oil imports -- is quite conceivable.

Such oil import reduction is essential if Kenya is to free up the capital necessary to raise domestic public and private investment to levels adequate to support employment growth at least equal to Kenya's rapid population growth.

III. FUELWOOD AND AGROFORESTRY

A. Costs of Deforestation

Although the data do not exist in Kenya to permit such calculations, studies in Sri Lanka and elsewhere have shown a clear, quantifiable relationship between deforestation, attendant soil erosion, and consequent economic losses due to declining agricultural productivity, premature dam siltation, lessened extension of climatic moisture, loss of wildlife habitat, etc. World Bank project feasibility studies in Mali and other countries strongly suggest that in Africa the benefits of afforestation -- expressed in terms of avoidance of the economic losses due to deforestation -- far outweigh the costs of afforestation projects.

As discussed in the Environmental Analysis, physical studies suggest that this cost-benefit relationship applies to Kenya. Dr. George Ongweny's studies of environmental impacts in the Tana River Basin establish a clear relationship between deforestation and soil erosion and, by implication, loss of agricultural productivity and premature dam siltation. While there is divergent opinion on the issue, many experts believe that premature siltation is largely responsible for periodic electric power blackouts and certainly has both reduced the useful life of the Tana River hydropower dams and contributed to the need to construct expensive upstream holding reservoirs. It also appears that the coral reef off Malindi -- a major tourist attraction -- is in danger of dying because of silt buildup. Finally, deforestation -- loss of both upland forest and savannah woodland -- means destruction of wildlife habitat in a country in which wildlife-oriented tourism is a major source of foreign exchange. The effects of deforestation are immediately

Visible in areas such as Machakos, where farms established on steep slopes must be abandoned in often as little as five years due to loss of topsoil and where residents believe that rainfall has declined since trees were removed wholesale to establish such farms.

B. Microeconomic Considerations Relating to Woodfuel Development in Kenya

Tree planting and care outside GOK gazetted forests must be done by individuals or communal groups. The time and effort that they devote to woodfuel development ultimately will depend upon individual socioeconomic responses Also, the choice between charcoal production or direct use of firewood -- which can significantly influence the energy efficiency of the overall woodfuel system-- ultimately is an individual, largely economic decision.

Production of Firewood or Charcoal as a Cash Crop

Presumably owners of productive agricultural land whose farms are large enough to generate a surplus in excess of the households' own needs, will decide what to plant based on percieved net economic returns after costs of production. Let us assume, to simplify, that a farmer's three choices are to produce firewood, charcoal, or grain.

Grain has a relatively high value/weight ratio and thus transport costs are not a major factor in total delivered grain costs. Wood, on the other hand, has a low value/weight ratio; and therefore, as mileage to the point of sale increases, transport costs rapidly become a dominant factor in determining total delivered cost. Conversion to charcoal entails an added processing cost -- labor, in some cases amortization of capital equipment, and energy losses during processing -- which may or may not be made up during its utilization. Thus, to the individual farmer, what to produce will be a function of costs of production, prices for which the delivered commodity can be sold, and transport costs.

Figure C-1 presents generalized price relationships between woodfuel, charcoal and grain that may occur in Kenya.

Let us first assume that land with potential for production of wood, charcoal or grain is located at A and, for the sake of argument, that no alternative sources of supply enter into competition. The relative market value for the three products at the place of production is shown as the departing point for the three valuesat A. The value of firewood produced from one hectare is less than that of charcoal, otherwise it would not be worth producing the latter. Much higher in value at the production site, the curve for grain does not climb nearly as steeply as curves for firewood and charcoal. If sold at a remote location, F, the grain will not fetch much more money than at the site of production.

The above curves for production from one hectare are relevant to the producer facing alternative uses of his land. More relevant from a consumption point of view is the curve showing the value of charcoal output from two hectares, since this is about what would be required to equal the productic in terms of energy, of one hectare of firewood.

Let us now try to draw some practical conclusions from these simplified price relationships.

A consumer at A will use only firewood for cooking. It would cost him twelve times as much to obtain the same heat content from charcoal. A consumer at D, on the other hand, would be able to purchase the same amount of energy as cheaply in the form of charcoal as firewood, and he would probably consider charcoal more convenient. At the remote location F, charcoal would be the most economic fuel.

For the producer facing alternative uses of land at A, the situation would look different. If all the land were of equal fertility, it would be most profitable to produce grain, next but not far behind would come charcoal, and last firewood except for his personal use.

At F, a different situation arises, If some land is available between E and F for cultivation in the suburbs of this consumer center, it could be used more profitably for producing firewood than for growing a grain crop. All forms of woodfuel are costly at F because of the long transport distance. Fuelwood produced within a shorter distance from the town G than from the distance C-G, would become cheaper fuel than charcoal supplied from A. Firewood supplied from within a distance less than D-G would be a cheaper fuel than charcoal produced anywhere.

The real life situation obviously is considerably more complex than what has been shown by this demonstration. No broad wood marketing and distribution system exists in urban areas, and most charcoal production uses "free" wood from "public" lands. Furthermore we have, as an oversimplification, assumed that all land at least technically is equally suitable for production of grain crops, firewood, or charcoal. In fact, certain areas generally are particularly suitable for one kind of production whereas other areas are suitable for a different use. Such oversimplifications need not, however, detract from general points.

All else being equal, firewood is the most economical of wood-derived fuels where it can be produced within a reasonable distance from consumer centers. Charcoal is an extremely wasteful fuel in terms of land resources necessary for its production. It becomes competitive with firewood only if the distance from the forest to the consumer is excessively long -- or possibly in urban areas where consumers are unwilling to burn wood because

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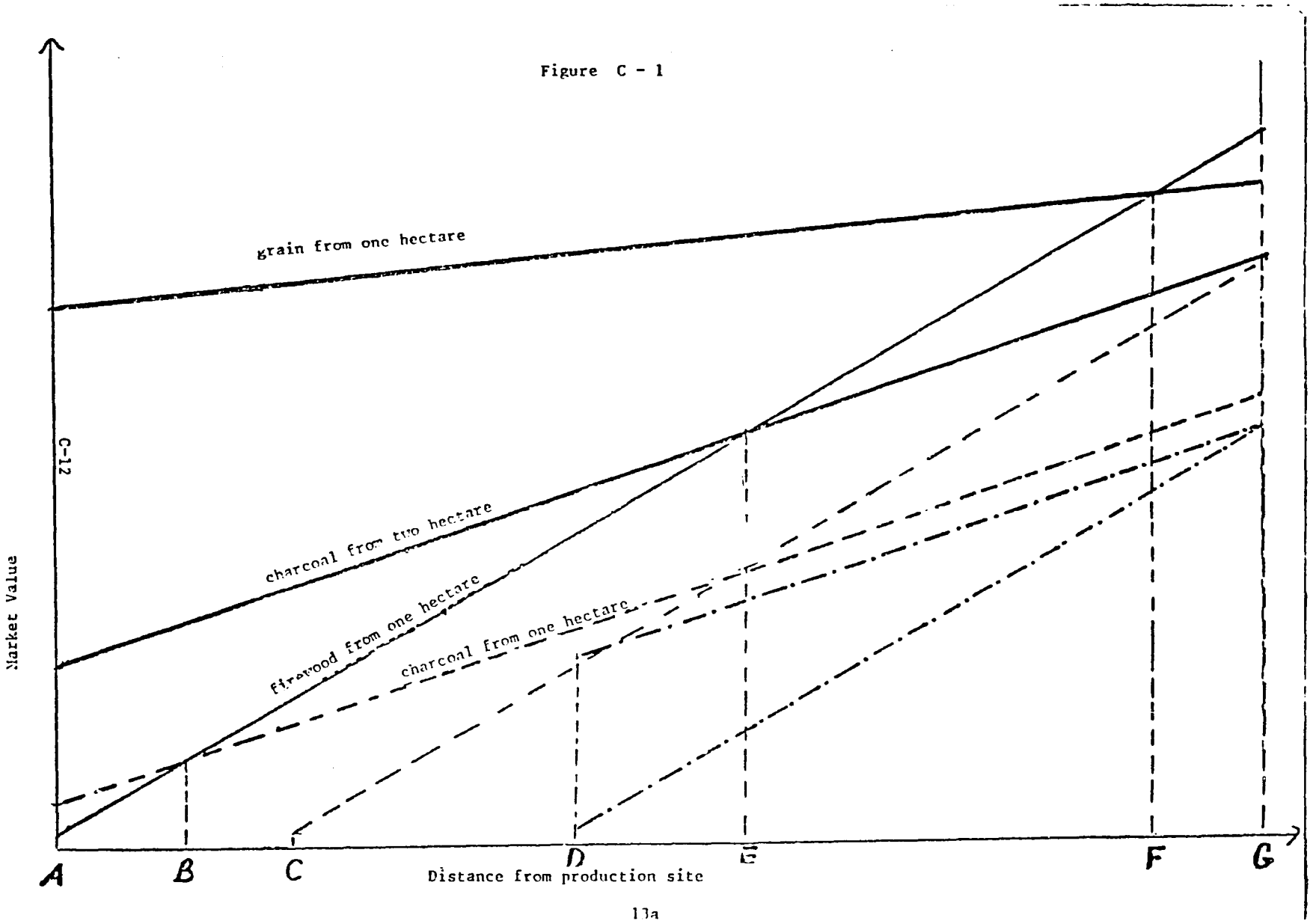
1) This, again, is an oversimplification. In particular, grain requires more intensive cultivation, weeding, and fertilization, while wood harvesting/processing costs are likely to be higher than for grains.

Figure C - 1



C-12

of percieved inconvenience or other noneconomic factors. Close to a large consumer center, firewood crops may offer greater economic opportunity than even grain crops.

Table C-4 applies fairly realistic numbers for Nairobi to this example. Assume productive farm on the immediate outskirts of Nariobi can produce 2.5 ton/ha of maize or 14 tons/ha (20 m^3/ha) of firewood, which alternatively would be converted to a portable steel kiln (20% yield by weight) into 2.8 tons/ha of charcoal. At the prices shown, this farm -- which we unrealistically assume incurs no transportation costs to ship to downtown Nairobi -- would be much better off producing firewood than producing either charcoal or maize. Assuming round-trip transport costs of KSh 10 per ton-kilometer, firewood shipped to Nairobi would remain the optimum crop for farms up to a radius of roughly 120 miles (200 kilometers) from Nairobi.

TABLE C-4
COMPARATIVE REVENUES FROM
MAIZE, FIREWOOD, AND CHARCOAL

	Yield (tons/ha)	Price (Ksh/ton)	Revenues per hectare
Maize	2.5[1]	907[4]	2268
Firewood	14[2]	336[5]	4704
Charcoal	2.8[3]	993[6]	2612

1. G. Tidrick, "Kenya: Issues in Agricultural Development" 1980; average large farm yield is 2.1 tons/ha.
2. 20 m^3/ha, roughly what GOK plantations achieve for sawtimber. Potential fuelwood yields could be as high as 40 m³/ha.
3. Assumes 20% charcoal yield by weight (achievable using portable steel kilns).
4. 8/20/80 producer price of Ksh 90 per 90-kilo bag.
5. Assumes charcoal at 7000 Kcal/kg, green wood at 3000 Kcal/kg, pricing of firewood bases on price per Kcal of charcoal less 15% because wood is convenient and costs more to distribute. The present retail price for firewood in Nairobi is Ksh. 500-550 per ton, vs. Ksh 100 per ton in early 1977.
6. Price to distributor of Ksh 35 per 34-kilo bag. Delivered retail price is Ksh 45-50 per 34-kilo bag.

The point of the above analysis is that it can be profitable to produce trees on cropland. A commonly held assumption is that fuelwood production must be confined to land of lower agricultural potential -- that is, to areas outside the highlands and the fertile strip -- where lower rainfall or less fertile soil or both render the land less useful for other purposes. There are three

reasons for questioning this approach to land use planning. Most wood currently covers from highland areas; and, as the above example illustrates, there can be cases where wood is the best cash crop. Second, most marginal land is for obvious reason located far from where the people who use fuelwood live. Transport from such distance rapidly adds to fuel prices. Third, even where marginal land is located near population concentrations (for example, south and east of Nairobi or inland from Mombasa), the same conditions which are adverse to crop production are likely to make the land poorly suited to tree production as well. The productivity of natural woodland in areas of Kenya where annualprecipitation is less than 800 mm and/or where soil conditions are unattractive to farmers probably rarely exceeds 2.5m^3 per hectare per annum; and over vast areas it is much lower. Producing tens of millions of cubic meters on such land would require enormous areas that would have to be properaly managed on a sustained yield basis. The land requirement alone would necessitate very long transport and hence high delivered fuel costs.

Integration of Trees with Food or Fodder Crops

To meet expected long-term needs discussed elsewhere in this paper, it will be necessary to reforest at least 20,000 square kilometers. Out of a total highland area of around 80,000 square kilometers, this seems far too much to take away from cropfarming and animal husbandry in a country that needs both to grow more food for its expanding population and to expand export-oriented agricultural production.

Most farmland in the highlands includes patches of marginal land covered by natural shrub and grass vegetation of little value to farmers. Such patches typically include stony ground, steep slopes, or formerly good farmland made unsuitable for cropfarming by erosion. To reforest such land and make it productive in terms of fuelwood, timber, fodder, beekeeping, and related activities would often be profitable, in addition to preventing further land degradation. How much land of this description could be made available is unknown, but it would appear to constitute a significant proportion of the highland areas. Not enough, however, to solve the fuelwood problem.

The problem is this: How can we reserve an adequate proportion of the highlands and better lowlands areas in order to assure adequate fuelwood production while at the same time expanding food production at some 4 percent per year through the remainder of this century? It seems remotely related to the problem of having your cake and eating it too. Nevertheless there seems to be considerable scope for achieving just that.

Experiments carried out elsewhere, in particular at the International Institute for Tropical Agriculture in Nigeria, in Rwanda, the Phillipines, and Hawaii, suggest that under environmnetal conditions similar to those characterizing most farmland is Kenya, it may be possible to increase food production by devoting 10% or even more of the land to trees.

In the east of Hawaii, Prosopis sp. growing on marginal land receiving rainfall of around 300 mm per annum, produces, in addition to on the order of 10m^3 per annum, 5-25 tonnes of pods per hectare per annum of a fodder value comparable to that of barley. Comparable results could be achieved in some areas of Kenya, at low and intermediate elevation, where the land at present is used for extensive ranching. If Prosopis sp. could be introduced successfully in such areas, their productivity might be enhanced not only in terms of livestock production but also in terms of production of fuelwood of an excellent quality.

At the International Institute of Tropical Agriculture in Ibadan, Nigeria, strips of Leucaena leucocephalis spaced 4-8 metres apart are grown in a two-year coppice rotation within agricultural crops such as maize and beans. The trees may occupy close to 10% of the land area, and the fuelwood and fodder output from the Leucaena is considerable. Nevertheless, the trees exercise such a strong fertilizing effect on the soil that the output of grain crops is higher than on land devoted entirely to these crops with no introduction of trees. Such an agroforestry system where trees ensure the maintenance of fertility without requiring other inputs on any scale, is of particular interest to farmers in countries such as Kenya that rarely can afford to use the large amounts of fertilizer that otherwise would be required to sustain productivity.

In Kenya, where many farms are located on steep slopes, agroforestry systems can be expected to prove even more useful than on the gently rolling hills near Ibadan. Rows of suitable multiple purpose trees planted along contour lines constitute one of the most effective methods for erosion control, in addition to the other benefits discussed above. Trees of a number of species and varieties other than Leucaena could be introduced beneficially on many types of Kenyan farm and range land, enhancing crop and livestock production while at the same time producing needed fuelwood.

The following are achievable production figures per hectare for alternative fuelwood production systems:

- Marginal land at low and intermediate elevation	5-10 m^3 fuelwood, 5-10 tonnes fodder.
- Marginal patches in highlands	10-15 m^3 fuelwood.
- Within highland forest reserves	20-40 m^3 fuelwood.
- Within agroforestry systems	10 m^3 per hectare of land actually covered by trees, 5 tonnes fodder, 5 tonnes mulch for erosion control and maintenance of soil fertility.

Data are not available to tell how much land for tree planting can be obtained by making use of "marginal patches" and by integrating trees into farming systems where it would be profitable to do so. A figure of 10-15% of the high and medium potential land would appear to be at least plausible. Together with improved productivity on existing forest reserves, afforestation of marginal lands, and aggressive efforts to use wood more efficiently, this conceivably could be sufficient to meet Kenya's needs.

III. OTHER RENEWABLE ENERGY

A. Cookstoves

Dissemination of improved cookstoves offers perhaps the most rapid means of reducing the rate of growth of deforestation and its consequent economic losses. At the same time, these savings (losses avoided) are external to (that is, not reaped by) the cookstove user and thus are unlikely to affect his/her economic decision making. However, based purely on individual economic analysis, one still would conclude that improved cookstoves both potentially offer significant benefits to their users (particularly the rural and urban poor) and should be likely to be adopted quickly. In fact, however, improved cookstoves have not been adopted quickly or easily, for reasons examined in the Social Soundness Analysis.

Use of wood fuel for cooking imposes a direct cost to the user in either of two ways. For most rural households, including virtually all the rural poor, wood is collected from the forests and burned in a three -stone fire. Women, who collect virtually all firewood for household use, may have to spend up to twenty hours per week[1] collecting firewood, in addition to what may be even more time to collect water. This collection time represents a cost , since it prevents rural women from undertaking other productive (or, less likely, leisure) activities. For most urban households and a relatively small proportion of rural households, on the other hand, cooking entails a money cost. These households must purchase charcoal, or in some cases firewood, and at least in the case of charcoal also must purchase the cooking device (metal jiko). Economic analysis of improved cookstoves must take the differences in the nature of these two costs into account. In both cases the time or money saved far exceeds the time/money "investment."

"Free" Owner-Built Woodstoves

On the assumption that most rural households collecting firewood are wholly or largely outside the money economy, most extension organizations have concentrated on development of owner-built cookstoves -- generally of mud, clay, dung, or acombination of these materials -- which require no money investment. As discussed in Annex A, in fact many stoves so developed (such as the Karai stove) do require some purchased parts; and most involve a considerable expenditure of time to construct (say, 40 hours). Most designs potentially could improve the efficiency of the three-stone fire by 30-50% (from around 10% to 12-15%). At the same time, Annex A illustrates that there is in fact a spectrum of alternatives ranging from very simple, low-time expenditure modifications to three-stone fires (e.g., the horseshoe alcove) to more elaborate, time-consuming stove designs.

1 The 1978 Kenya Rural Survey found that over 40% of those interviewed walked over over 1 hour to collect firewood, almost 20% walked over 2 hrs., and 10% over 3 hrs.

Simplifying greatly from real life as described in the Social Soundness Analysis, one can visualize that, in deciding whether to invest time to construct a new stove or stove modification, a woman reached by extension would access the estimated construction time, likely/possible reduction in firewood collection and/or cooking time, uncertainty and perceived risks, and "hassles" involving changes in cooking techniques. One can express these in economic terms as a capital expenditure (time to construct), stream of operating savings (reduction in wood collection and possibly cooking time), and an internal rate of return (which would be adjusted downward to account for perceived uncertainties, "hassles" etc.) One then can use such analysis to assess the likelihood of various stoves being adopted.

For example, assuming a "typical" woman residing in rural Kenya spends an average of ten hours collecting firewood, weekly, her total annual expenditure of time amounts to 520 hours. Simplifying greatly, assume that she knows of two alternatives. One involves an estimated investment of 8 hours to construct a horseshoe alcove which she feels would be fairly likely to reduce fuelwood consumption by 10%; the other is a new stove design which requires an estimated 40 hours to construct and she feels could reduce fuelwood consumption by 30%. Assuming both alternatives would last one year, the first alternative (commit 8 hours to save 52 hours or 4.33hours per month) would pay back after two months and have an internal rate of return of over 17,000% (53.8% per month). The second (commit 40 hours to save 156 hours, or 13 hours per month) would pay back after a little more than 3 months and have an internal rate of return of over 2600% (31.3% per month), discounted by a factor for hassles and uncertainties[1]. On the face of it, both investments appear extremely attractive, though the first appears much more attractive -- yet, even when extension effort has been extensive, rural households have been relatively slow to build their own stoves. Thus, improved trial and owner built stoves cannot be judged soley on economic grounds.

Another important economic aspect of owner-built cookstoves is the cost of extension itself. In Senegal, a team of three (one Peace Corps person and two local extension workers) spend a week in a village of, say 50 households. Their cost including support and expenses should be at least $500-$1000 per village. Assuming that 40% of the householders eventually adopt an improved cookstove, the extension cost per stove would be $25-$50 per stove, far in excess of the cost of commerical jikos, Asian pottery braziers, etc. ($3-$10). Clearly, one hopes that the adoption rate will exceed 40% and that adoption will spread from village to village. However, such adoption must be fairly widespread for extension costs per stove to reach reasonable levels.

Monthly, rather than daily or weekly, compounding has been used only to keep the rates of return from being even more absurd than those shown.

Commercial Stoves

Presently, virtually the only commercial wood fuel stove sold in Kenya is the metal charcoal brazier (jiko). However, conceivably Asian pottery charcoal stoves, metal wood-burning stoves such as those used in Addis Ababa, or even high-mass earthen stoves could be produced commercially.

Jikos currently sell for around Ksh 25-40, depending upon size and the quality and thickness of scrap metal used. A high quality jiko may have a useful life of three years, although critical parts such as the bottom grate would require more frequent replacement. A poor quality jiko may last only 6-9 months.

Relative to the annual cost of charcoal, the jiko cost appears insignificant. A "34 Kilogram" standard burlap bag may cost KSh 1-1.5 per kilo at the retail level, while a smaller quantities may cost KSh 2 or more. The 1978 Rural Energy Survey estimated that average household charcoal consumption by province is 625-911 kilograms per year. This would imply an annual charcoal cost of KSh 625-1367 per year.

Some experts (such as Keith Openshaw of the University of Dar Es Salaam) project that a 40% more efficient charcoal brazier could be produced for the same cost as a jiko. Even assuming, however, that an improved jiko would cost an additional KSh 50 and that if improved efficiency by only 25%, the return on investment on a monthly compounded basis (assuming both jiko and improved jiko or other brazier last one year) would be in excess of 1300% even for the most conservative case. It appears economically attractive to spend more than twice -- and probably four to five times -- as much on an improved jiko. Again, however, the general feeling is that people will not act in this way, whether because of inability to accumulate that much cash at one time, the psychological shock of paying twice as much for what appears to be the same device, or other reasons.

Commercial Rural Woodstoves

A final category of stove could be commercial woodstoves which require the user to invest cash to reduce collection time. One cannot produce a conclusive economic analysis in this case, since the rates at which households at various income levels would be willing to substitute time for money is unknown. Intuitively, one would expect that poor households might have a very high time-money substitution rate (that is, they would be willing to invest substantial time) and that this substitution rate would decline as household income increased. The absolute values, however, are unknown. We also do not know at what implicit rate a rural householder would discount future savings. Taking the "owner built stove" example discussed earlier, would a rural household be willing to spend say KSh 350 (the quoted price of Karai stove) to reduce collection time by 156 hours per year? KSh 100? It is unclear

IV. CHARCOAL PRODUCTION

Though there are a few large or medium scale industrial producers, charcoal production in Kenya generally is carried out by small intermittent producers. Most such producers are unlicensed, and virtually all using traditional pit or earthen mound kilns of very low efficiency (typically 8-10% recovery on a weight-of-wood basis). The number of such producers is unknown.

Almost all attention in Kenya has focussed on somehow changing from small-scale intermittent production using traditional methods to larger-scale industrial production using stationary brick or portable metal kilns. Despite numerous industrial feasibility studies, demand for industrial kilns has not grown. Burns and Blane (Kenya) , Ltd., producers of the Mark V portable steel kiln, reportedly sell only 1-3 units per year within Kenya, primarily to industrial organizations which produce charcoal as a by-product of their primary operations.

As discussed below, for a small-scale charcoal producer extracting his wood feedstock from someone else's land or producing charcoal on a one-time basis as he clears his own land, only low-cost modifications to traditional methods are likely to appear economically attractive, and they appear quite attractive. Larger-scale production methods are uneconomic when production alone is considered. They make sense only as part of a sustained-yield plantation management system.

Should the GOK decide to pursue conversion to sustained-yield forest management and charcoal production systems, larger, more expensive kilns may both be economically attractive and provide a vehicle for promoting such conversion. Without a policy to encourage or force such conversion, however,non-traditional kilns are likely to continue to play only a minor role.

Modification to Traditional Production Methods

As discussed in the Technical Analysis, low-cost techniques have been developed in Kenya and elsewhere to improve yields from traditional charcoal production methods. An example is the use of flattened debes to provide a barrier between the wood stack and surrounding earth mound. At a cost of KSh 25-30, the producer may be able to increase his yield by 30%. Thus a producer formerly achieving 15 bags per firing could increase his yield per firing to 20 bags. At a price from the wholesaler/transporter of KSh 15 per bag, he would net an additional KSh 75 per firing. Thus, the modification would have earned a 200-300% return from the first firing alone. In fact, for a producer operating with any frequency, such modifications would be attractive even if yields increased by only 10%.

Metal Kilns

In contrast to the traditional kiln -- representing a small, low-cost, low yield, high-labor, long-running time operation -- portable steel kilns are larger, high-first-cost, high yield (15-20% recovery), low-running time systems. The present cost of a Mark V, including 15% sales tax, is

KSh 27,000. It will produce 24-32 bags of charcoal in a 72 hour cycle versus 10-20 bags on a 8-14 day cycle for traditional kilns.[1] It appears conceivable to construct a smaller, much less expensive metal kiln -- a 15 bag kiln for KSh 9000 -- but even this represents a high capital cost.

It is not at all clear that there are any traditional producers that would be capable of financing even the small steel kiln. If there were such a producer, he almost certainly would be operating multiple traditional kilns simultaneously, so the reduced operating cycle time would not be a significant benefit. He probably would employ wage labor, unlike the great majority of traditional producers. The savings thus would be in terms of wood collection and processing time saved per ton produced. Per firing, he may save one day of wood collection and cutting labor and perhaps 2-3 days of processing time.[2] Assuming almost continuous operation of the metal kiln, he could produce 1500 bags of charcoal per year from 100 firings. At 3-4 days per firing, he would have saved 300-400 days. Assuming a five year kiln life and a wage rate of KSh 20 per day for kiln laborers, he conceivably could save KSh 6000-8000 per year. Over the five-year period, this would represent a 60-85% return on investment on a discounted cash flow basis. This return could of course double -- or more likely disappear completely -- depending upon actual wage rates or labor opportunity costs, metal kiln maintenance costs, costs to move the "portable" kiln (roughly 1000lbs.), and other factors.

Large Scale Kilns

Larger scale kilns such as those at EATEC, which produce 50 tons of charcoal per firing at a 25% efficiency (by weight), are not comparable to earth kilns. They are stationary and hence require large sustained-yield plantations; they typically are high capital cost systems (although the capital cost per ton may not exceed that of a metal kiln), and they require an organized, specialized work force. They connot be introduced without simultaneously introduced sustained-yield plantation systems .

Kilns as Components of Sustained Yield Production Systems

Where an operator owns the land himself and foresees keeping it in forest production(as opposed to, say, clearing the land for farming), he may or may not perceive an incentive to preserve his productive base through the introduction of sustained-yield forest management techniques. This will depend on prices offered for wood, perceived soil erosion or other effects if he destroys his forest resources, and other factors. Presuming that he does desire to operate on a sustained-yield basis and that he is interested in charcoal production,

1. This time requirement may be misleading, since "large" traditional operators may have more than one kiln, at various stages of firing/cooling, operating at the same time.

2. Calculations by D.E. Earl showing much greater time savings assume the traditional producer operates only one kiln at a time, which does not reflect operations of the large traditional producers most likely to be able to afford a steel kiln.

he then has a substantially greater incentive to introduce more efficient charcoal production methods than if he regards wood in other people's forests as a "free good" which has but to be collected. In short, once a producer must take into account the costs of forest maintenance -- costs currently borne by the country as a whole in the form of the economic losses suffered as a result of deforestation --then he will have a much greater incentive to produce charcoal more efficiently. To illustrate, using kilns of the efficiency of those at EATEC (25% yield), a ten-hectare highland plantation producing 16.8 m^3 of roundwood per hectare on a sustained-yield basis (roughly the equivalent of the Forest Department's highland plantations) could produce 30 tons of charcoal per year, earning roughly KSh 12,000 per year (based on a price in the forest of KSh 15 per bag.) With traditional methods, the same plantation could produce only 12 ton of charcoal -- or KSh 4800 -- per year. Thus, the more efficient kiln would increase his revenues by KSh 7200 per year, or probably roughly the price of the kiln, in addition to saving labor and other costs discussed earlier.

The above examples also illustrate why there is little sustained-yield production of charcoal except as a by-product of other operations. In the context of the Fuelwood and Agroforestry discussion earlier in this section, the return per hectare from charcoal production -- KSh 1200 (US$171) per year if he sell to wholesalers/ distributors in the forest or roughly double that if he sells to distributors in Nairobi -- is an inadequate incentive except on lands unsuitable for other uses.

IV. WATER SUPPLY SYSTEMS

Distributors estimate that about 5000 water pumps are sold per year. Of this number, roughly 60 percent are powered by electric motors, 20 percent by diesel engines, and the remaining 20 percent by petrol engines.[1] Electric pumps are preferred because of their dependability and low operating costs. However, large sections of Kenya, including most areas not presently served by community water systems, lie outside the electric utility grid; and, for them; electric pumps are not an option. At the same time, diesel or petrol pumps entail high fuel costs, and, generally more serious, fairly demanding maintenance requirements. In fact, although figures are unavailable, some field experts estimate that one-third to one-half of diesel pumpsets installed in rural areas are out of service within a year of installation because of lack of spare parts or skilled maintenance engineers.

The high fuel costs and poor maintenance experience with diesel and petrol pumpsets has prompted interest in windmills, hydrams, solar pumps, and other renewable energy systems as alternative power sources for community water supply systems.

1 Davis and Shirtliffe Ltd. and Jos. Hansen and Soehne (EA) Ltd.

Windmills

Installed costs of windmills vary widely depending upon the make and model, desired storage capacity, etc. Prices for three roughly similar windmills are provided in Table C. Total water pumping systems costs could be 2-2.5 times this figure. For instance, in a current project in Tanzania using U.S. Dempster Windmills, the total system cost including well, water storage tank, piping, etc. is slightly more than twice the cost of the windmill alone.

TABLE C-5
COMPARATIVE CAPITAL COSTS
FOR THREE WINDMILLS

	Delivered Cost(US$)
Dempster - 12 foot (U.S.)	$2,500
Kijito - 12 foot	$4,861[1]
12 PU 500 (Kenya)	$3,958[2]

1. KSh 35,000
2. KSh 28,500

Of the two locally manufactured windmill types, the Kijito mill is by far the best known and has been used in this analysis. The twenty-foot Kijito mill is compared with a Lister LTI, one of the smallest diesel pumpsets used in Kenya. Both systems are assumed to serve a water system of 20,000 gallons, which could provide 90 litres of water per day to a population of 1000 people.

Table C-6 highlights the fact that capital costs of the Kijito pumping system are almost three times those of the diesel unit. However, the higher recurrent costs of the diesel unit -- fuel, operating labor, and maintenance -- result in lower total system lifetime costs for the wind unit. The costs of both systems meet in the sixth year of operation and thereafter the wind unit is significantly less expensive. Investors typically look for a shorter payback period than eight years. However, while the payback period is long and the discounted return for the incremental investment is low, alternative assumptions regarding fuel price escalation, diesel downtime, etc., could make the windmill appear to be an attractive investment.

Comparison of a windmill and diesel unit providing only 4000 gallons per day or(90 litres per day) to 200 people -- make the windmill look much better. The cost of the smaller Kijito system is only 1.22 times that of the diesel unit, since this size is below the limits at which diesel units can be scaled down easily.

TABLE C-6

Estimated Capital and Operating Costs

of Small Water Supply Scheme
(20,000 gallons per day)

		Wind powered	Diesel Powered
(1)	Windmill	Kshs. 70,000*	
(2)	Diesel engine		Kshs. 13,880*
	Base and pulleys		6,500
(3)	Pump		15,900
	Pump House		1,500
	Pipes	10,000	10,000
(4)	Storage tank	45,000	6,200
	Concrete foundation		500
	Installation	7,500	500
	Transportation	3,000	200
	Total	135,500	55,180

* Prices are inclusive of 15 percent sales tax
(1) Kijito windmill, 20 ft. rotor, Standard 30 ft. tower, Ma. 4HP output
(2) Lister LT1, air cooled engine, 2.5-7.0 BHP
(3) Southern Cross, 12" Stroke, HI-F
(4) Recommended storage capacity for a windpumping system is three times daily requirement. In this case it is assumed to be 20,000 gals. per day.

II. Essential Recurrent Costs (Kshs. per year)

		Wind powered	Diesel powered
(1)	Fuel		Kshs. 8,256
	Operation and Maintenance	Kshs. 2,080 (2)	8,277 (3)
	Depreciation	7,033 (4)	5,518
	Total	9,113	22,051

(1) At 1500 RPM fuel consumption is .87 litres per hour. The diesel engine is assumed to run 8 hours per day, 365 days per year. The present cost of diesel fuel in Nairobi is Kshs 3.25 per litre.
(2) Estimated at 2 percent of capital costs per year.
(3) Estimated at 15 percent of capital costs per year.
(4) Based on a linear write off of 15 years.
(5) Based on a linear write off of 10 years.

Windmill recurrent costs again are much lower than for the diesel unit, and the windmill pays for itself within two years of installation.

This analysis illustrates that the economic feasibility of windpower is particularly sensitive to the scale of operation required. Assuming adequate wind regimes and other appropriate site conditions, windpower will be increasingly attractive as the scale of operation declines. At the same time, since most of the remaining unserved rural population is scattered, it is likely that the typical scale of requirement will decline over time.

It should be noted that the Kijito mill is relatively new, and there are questions regarding its long-term maintenance requirements, useful life, etc. At the same time, for many models it currently is less expensive to import a well-known windmill model of proven reliability from the U.S., Australia, or Argentina. It also is possible, as in Cape Verde, to produce such standard windmill designsin small shops at approximately half the cost of the Kijito or imported windmill. It thus appears that there is scope for production of windmills within Kenya which would be competitive with diesel pumpsets over at least the low end of the system capacity range.

Hydraulic Rams

If windmills are competitive at fairly small system sizes , hydrams may be thought of as being competitive at extremely small system sizes. They also are very site-specific, since they can only be used where there is a sufficient supply of falling water to power the unit to lift some of the water uphill. They thus, potentially fill a niche of requirements where gravity feed systems cannot be used (typically because some people live above the flowing-water source) but the requirement is too small to be met by diesel. Such applications generally are found on mountain slopes, often forested, where windpower cannot be used.

Hydram costs generally range from KSh 4000 to KSh 16,500, although used units often are available at substantially lower costs. This compares with KSh 34,500 for the small (4000 gallon per day) windmill analyzed above.

Hydrams generally are assumed to be especially suited to use in remote or inaccessible areas, since they require no operator and little maintenance. Also, the useful life of a hydram generally is assumed to be 30-50 years. In fact, however, the project team found that over half of the hydrams surveyed were out of service because of lack of simple maintenance (e.g., cleaning leaves and other debris from the inlet) or because a worn seal had not been replaced.

Solar Stills

Solar distillation units require a relatively high capital investment per unit capacity. However, if well designed and constructed recurrent costs are very low. Initial costs depend on a number of factors including local materials availability and suitability, local labor costs and productivity, imported materials

required. size of plant, etc. Some indicative costs are the following: the material and labor costs of building a solar still in India were $7.50/m^2 in 1966 and$11.50 in 1975, including the cost of reservoirs. Solar still capital costs in Greece, Pakistan and the Caribbean have been reported at between $16.00 and $32.00/m^2 in 1977..

Recurring costs depend on amortization of the initial investment, interest rates and the cost of operating and maintaining the unit. Depending on the durability of the materials used, the useful life of a solar still is usually between 5 and 20 years. If glass, masonry and a durable basin liner are used, the service life can easily be 20 years. Based on experience in the field, operation and maintenance costs should be figured at 1% of the initial investment with an additional 1 person day of labor per year for every 10 square meters of still area.

Solar still productivity is normally independent of the size of the plant. It is,rather, dependent on the duration and intensity of solar radiation received. Average annual productivity in potential areas of use in Kenya will be about 3.0 liter/M^2/day.

It is difficult to be specific about the cost of water produced unless the design parameters and materials and labor costs are known for a specific project. In practice this cost has ranged from $1.00 to $3.00 per 1,000 liters produced. This cost is generally competitive when compared with the costs of designated water from large fossil-fuel fired desalination plants. The cost of solar desalinated water is well below the cost of desalinated water from small fossil fuel fired units. The balance is continually swinging in favor of solar distillation systems as fossil fuel costs increase.

Solar Pumps

Solar pumps are of two types: thermodynamic and photovoltaic. The thermodynamic systems, typified by the Rankine cycle "sofretes" pump generate on the temperature difference between a solar heated fluid and the cold ground water. The apparatus to accomplish pumping from such a thermodynamic cycle is sophisticated and expensive. Typical costs of larger Sofretes pumps is in the order of $20,000 per kilowatt of installed capacity. The smaller pumps 1 to 2 KW in capacity are consiberably more expensive. As with all sophisticated technologies these pumping systems require a considerable amount of maintenance and upkeep to keep them working. The level of technical expertise required for such maintenance is high thus, if they are to be used they must be sited where adequate technical service is available. Experience to date with these systems has been variable. Where technicians are sufficiently; trained and available, these pumps operate satisfactorily. Where technicians must be brought in, to, for example, remote areas, these pumps have had major maintenance problems and system shut down is common. For these reasons, these thermodynamic cycle pumps are not recommended for this project.

Photovolataic pumps, on the other hand, are reliable, require little maintenance beyond routine inspections and fit in more with conventional maintenance and operation procedures. However, they are costly. Present costs are about $12 to $20 per watt of installed pumping capacity, however, this cost is dropping rapidly. They are expected to be economically competitive with other pumping systems within five years for accessible sites and are marginally competitive even today for remote sites. The pumps associated with photovoltaic arrays are conventional electric water pumps. Experience to date has revealed that maintenance is minimal and the systems are well accepted where they have been installed. They depend on the availability of adequate direct sunlight so their areas of use for year round water provision will have to be carefully selected.

Biogas

Biogas units for individual or farm use are well beyond the means of AID target population groups. Costs are roughly $48.50 per cubic meter for gas from a Hutchinson biogas digester and $52-55 for a gas from a Chinese digester. The capital cost of Hutchinson's units, according to a time 1980 price quotation, vary from KSh 15,000 ($2083) to KSh 40,000 ($5555). Also, Hutchinson estimates that, using his units, 30 cows would be required to provide enough gas to replace one gallon of diesel per day.

As estimated by a recent German technical assistance team, a Chinese dome-type biogas plant could be installed for roughly KSh 4000 ($550). However, the cost of the gas per cubic meter is $55, or higher than the estimated cost from a Hutchinson unit (Table C-7)

Power Alcohol

Like biomass, power alcohol is beyond the means of AID's target population groups. Table C-8 summarizes World Bank estimates of costs and other parameters for various ethanol plants. Estimated capital costs are roughly seven to eleven million dollars for a medium cost country.)

Table C-7

ESTIMATED COSTS OF A CHINESE BIOGAS DIGESTER

(Source: GATE MODULE- BIOGAS FOR DEVELOPING COUNTRIES, 1980)

List of Materials	CHINESE Dome type biogas plants				
	digester volume 6 m^3	Digester volume 10m^3	Digester volume 50 m^3	Cost per unit in Kenya for	Estimated Cost for 10m^3 Digesta inKenya
Masonry 5.0 m^3	5.0m^3	6.4 m^3	20m^3		
Bricks(20 x 5 x10 cm)	5000	6500	20000	1.25	sh1625/-
Cement > Lime	280kg	360kg	1100 kg	sh 45 per 45kg bag	360/-
Sand	2700 kg	2100 kg	8400 kg	sh 50 per ton	105/-
Internal plastering	A-25m^2 0.8 m^3	A- 31m^2 1.0 m^3	A- 89m^2 2.5 m^3		
Cement > Lime	200 kg	250 kg	600 kg	sh 45 per 45 kg bag	250/-
Sand	1200 kg	1500 kg	4000kg	sh 50 per ton	75/-
Paint (Bituminous)	70 kg	95 kg	270 kg	sh 200/unit	200/-
1" gas pipe	1.5 m	1.5 m	1.5 m	sh 10/meter	15/-
Gas tap				sh 30/unit	30/-
Plastic pipe				sh 100/unit	100/-
(10 m^3 plant) Labor 50 mandays (Source ITDG-11E2 Chinese Biogas Plant)				Sh 600/month	Sh 1200/-
				TOTAL COST IN KENYA	SH3960/- (US $550)
				PRICE/C.U.M.--SH396,	(US $55)

Table G-8

KEY PARAMETERS OF ETHANOL PRODUCTION FROM DIFFERENT BIOMASS MATERIALS

	Unit	Molasses	Sugarcane	Cassava a/	Corn a/
A. YIELDS					
Ethanol Yield/ton of Biomass	liters/ton	270	70	180	370
Biomass Yield/ha of Land b/	tons/ha	n.a.	50	12	6
Ethanol Yield/ha of Land	liters/ha	n.a.	3,500	2,160	2,220
B. PROCESSING PLANTS					
Economic Plant Size Range	liters/day	60-240,000	120-240,000	60-120,000	120-240,000
Number of Operating Days	days/year	180	180	275	275
Annual Production in 120,000 liters/day Plant:	- million liters/year	21.6	21.6	33.0	33.0
	- million US gallons/year	5.7	5.7	6.9	6.9
	- tons/year	17,100	17,100	26,100	26,100
Installed Cost of 120,000 liters/day Plant in:					
- Low Cost Countries c/	US$millions	6.8	7.6	9.1	9.1
- Medium Cost Countries c/	US$millions	7.6	9.5	11.4	11.4
- High Cost Countries c/	US$millions	11.4	14.3	17.2	17.2
C. ECONOMICS AS GASOLINE ADDITIVE					
Ex-Plant Biomass Raw Material Cost for 10% ERR d/					
- At US$31/bbl FOB Crude e/	US$/ton	62	14	13	neg.
- At US$35/bbl FOB Crude e/	US$/ton	70	16	17	1.2 f/
- At US$43/bbl FOB Crude e/	US$/ton	85	20	23	1.8 f/
Ex-Plant Biomass Raw Material Cost for 15% IRR d/					
- At US$31/bbl FOB Crude e/	US$/ton	65	14	16	neg.
- At US$35/bbl FOB Crude e/	US$/ton	73	17	19	1.4 f/
- At US$43/bbl FOB Crude e/	US$/ton	90	22	25	2.1 f/

a/ Based on current designs and fuel oil as fuel source.
b/ Based on current average yields in Brazil, except for corn which is based on US average.
c/ Low cost country data for sugarcane plants based on Brazil costs, others on data supplied by various sources and extrapolations by Bank staff. All costs in late-1979 Dollars.
d/ For medium cost countries.
e/ Assuming ethanol value equal to that of gasoline in volume terms. Gasoline price assumed as 1.3 times that of ex-refinery light Arabian Crude price, by volume: this relationship assumed to go down with increased crude prices. Crude price assumed to increase at 3% p.a. in real terms, gasoline price at 2.5% p.a., and raw material cost at 1.0% p.a.
f/ For corn US$/bushel. One bushel weighs 56 lbs. One ton equivalent to 39.4 bushels.

World Bank

Industrial Projects Department

May 1980

ANNEX D. ADMINISTRATIVE/INSTITUTIONAL FEASIBILITY

I. INTRODUCTION

There are several administrative issues or potential constraints which are critical to the success or failure of the project.

First, the Ministry of Energy is new, relatively small, and still in the process of developing its policies and programs as well as its relationships with other ministries. Since energy is an input to virtually all human activity, many other ministries have ongoing operations which relate directly to the activities recommended in the project. The project presumes that the Ministry of Energy is in a position to act as technical advisor to several ministries and to rely on other ministries operating programs to achieve energy policy objectives. However, experience with other programs suggests that interministerial cooperation is not easy. Both a formal interministerial coordination mechanism and close informal cooperation and mutual trust must be established.

In addition to interministerial coordination, coordination and communication lines must be kept open among the numerous donors which have initiated or are planning energy related projects. Otherwise, there is a risk of duplication, conflicting programs, and excessive demands placed on the MOE's small staff.

Another critical administrative issue and a central component of the project is extension of renewable energy technologies to the poor. Many ministries, particularly the Ministry of Agriculture, have well-established rural extension networks. Still, while progress has been made, there are difficulties in reaching the poorest families that constitute AID's target groups.

The following sections address each of the major project components.

II. INITIAL PLANNING AND SURVEYS

Since the MOE is new, energy planning and policy capabilities are in the formative stages. Its Policy, Monitoring and Planning Division currently has four full-time professionals and has budget approval for four more during 1980. Two staff members, including the acting director, have attended AID's Energy Management Training Program at SUNY Stony Brook and are familiar with the AL-EDIS energy assessment system. One economist currently is assigned full-time to energy conservation, a new field for him. Additional training will be required in operation and use of the AL-EDIS system, in operation and use of the Data Bank and Library, and in energy conservation analysis.

In addition to the Energy Planning and Conservation Expert and short-term consultants to be provided under this project, the MOE is likely to receive policy planning assistance from the UN, EEC and possibly other donors. The combined assistance should enable MOE to develop an effective energy planning capability.

There are three potential problem areas. First, it is important that the MOE be able to monitor energy consumption patterns in all sectors. It should work closely with CBS in incorporating energy modules into existing surveys, such as the Industrial Survey now being conducted and any urban surveys which might be undertaken, as well as support CBS's efforts to conduct rural energy surveys.

In addition, shaping national energy conservation policy will require close cooperation with the Ministry of Economic Planning and Development, Ministry of Finance, and those ministries paralleling the major energy consuming sectors, e.g., Industry, Agriculture, Transport and Communications, and Commerce. Establishing such relationships will require time, effort and considerable diplomacy. The MOE appears to have made a good start through its interministerial energy conservation committees.

Second, economists and statisticians cannot be hired directly by the MOE. Rather, they are seconded by the Ministry of Economic Planning and Development. MEPD has provided assurances that those seconded to MOE will be kept there as long as the MOE is satisfied with their performance.

Finally, a multiplicity of donor efforts in providing planning assistance runs the risk of not only duplication but inconsistent or even contradictory advice and excessive demands on MOE management time. MOE appears to recognize that it must aggressively direct and coordinate donor activities.

III. INSTITUTIONAL DEVELOPMENT

The Ministry of Energy presently has a total staff in place of less than 100 and has an authorized staff of less that 150. With this relatively small staff, it must launch initiatives in many different areas. Also, since energy is an input into virtually all human activity, MOE's interests cut across the interests and ongoing operations of virtually every other ministry. At the same, these ministries generally lack technical information and experience in the energy-related aspects of their programs.

If it is to launch effective intiatives outside those areas such as electric power where it already has ongoing programs, the MOE must work with and through those ministries who already have directly related programs. In some areas, non-governmental organizations also constitute important resources on which the MOE can draw.

The MOE will need to work closely with other GOK ministries and non-governmental organizations to help them identify and implement appropriate conservation activities, identify potential renewable energy applications, improve the technical grounding and awareness of government extension workers and field staffs of non-governmental organizations through technical assistance and training/curriculum development, and assist in developing projects and programs for financing through the Energy Development Fund. Based on this role of MOE as an advisory and initiating organization working primarily with and through others, the project at least initially will place the four long-term experts (in afforestation/forest management, agroforestry, wood/charcoal conversion and end-use devices, and renewable energy water pumping systems) and short-term consultants in the MOE, with the understanding that most of their time will be spent working with other ministries or with NGO's.

One of the first tasks of the long-term experts should be to work with MOE and respective extension ministries to develop specific implementation schedules for development and introduction of renewable energy curricula at the extension training centers (e.g., KIA, Coast Training Institute, Karen VTU, Farmers Training Centers, and Forest Training Center) and relevant training institutions (e.g., Egerton College, Agricultural Institutes, Institutes of Technology, and Village Polytechnics) and for carrying out visits to and informal surveys of field extension activities. Such joint implementation planning will serve both to program the efforts of the long-term and short-term experts and also to provide a specific focus around which interministerial cooperation can take place.

Pursuing such an advisory/initiator role poses risks for both MOE and the project. Operating ministries may spurn MOE offers of assistance, or they may be reluctant to direct their extension or other resources to energy from whatever they currently are working on. Also, as in most other countries, in Kenya the power of a government organization generally is related to its size and the nature and scope of its operating programs. Over time, the MOE may become dissatisfied with an advisory role and try to launch its own operating program, for example in fuelwood. Should it do so, it is much more likely to be viewed by other ministries as a competitor, and its ability to work with or through them in other areas will suffer.

It is conceivable that interministerial cooperation is so difficult to achieve--whether because of other ministries' reluctance or MOE's desire to establish its own operating programs--that project experts can be effective only if they are assigned to operating ministries. The most likely such ministry would be Agriculture in view of its ongoing programs in nursery development, agroforestry, small-scale irrigation, farm extension, and women's extension. Splitting up the project experts, however, would make it difficult to achieve the desired integration among the various renewable energy disciplines which the experts represent.

The most important organizations in each major area of renewable energy are discussed below:

Fuelwood/Agroforestry

The Forest Department of the Ministry of Environment and Natural Resources manages Kenya's gazetted forests, from which over 10 percent of the country's fuelwood is produced. Both it and the Ministry of Agriculture operate rural afforestation nursery and extension services. The Ministry of Agriculture also is involved in trying to get farmers to integrate trees into their farming practices (agroforestry). Finally, a number of nongovernmental organizations have tree planting and in at least one case, nursery programs of varying effectiveness. All of these represent potential resources in a fuelwood program.

The Forest Department of the Ministry of Environment and Natural Resources traditionally has concentrated its attention on preservation of natural highland forests as a water catchment area protection measure and on production of saw timber and pulpwood from plantations or from a few natural forest areas. As a consequence, most Forest Department attention--and virtually all its forest officer education--has been focussed on the gazetted forests. Within the past three years, it has launched a Rural Afforestation Extension scheme (RAES) which currently has an extension officer and at least one nursery per district. The Forest Department is supposed to work with County Councils to help manage lands set aside by the County Council for afforestation, although so far the limited resources allocated to RAES have not enabled it to do so.

The Ministry of Agriculture, as part of its soil conservation program, has expanded its nursery and afforestation program, going from a small program concentrating on fruit trees to a program with two to four nurseries in each of 28 districts, all producing seedlings for multipurpose trees as well as fruit trees. Because the program is aimed largely at areas of highest soil erosion potential, Agriculture nurseries tend to be located in marginal areas undergoing rapid population expansion, while Forest Department nurseries are more likely to be found in the highlands. The Ministry of Agriculture also is working to introduce afforestation as an important program element into its farmer training and extension efforts and its small-scale irrigation schemes.

Nongovernmental organizations such as the NCCK, NCWK, Wildlife Clubs of Kenya, and others have launched tree-planting programs, oriented primarily to community and school groups.

There appears to be some cooperation among these various government and nongovernmental organizations, primarily at the District level or below. There are a few instances of Agriculture and the Forest Department working together on specific projects, and both organizations' nurseries supplying seedlings to nongovernmental groups.

Since fuelwood development must address gazetted forests (Forest Department), community planting (all organizations), and integration of trees into cropping and livestock systems (Agriculture and probably also Livestock Development), MOE must work with all these organizations. In working with the government organizations, MOE may run into suspicion that it wants to get into nursery and fuelwood plantation operations itself. This in fact does not appear feasible. The MOE currently is only about one percent of the size of the Forest Department and a much smaller fraction of the Ministry of Agriculture. To try to duplicate their operation potentially would mean a delay of many years. Thus, the preferred course is to build up and where necessary reorient Forest Department and MOA operations rather than launch a new operating entity in MOE.

Working with or through nongovernmental organizations is a complementary step to working through Agriculture or the Forest Department. While they lack the large-scale operations ability (e.g., nurseries) or full-time extension staffs characteristic of government, these organizations can mobilize local interest and activity and provide important local feedback. Since it is likely that some of these local groups are not reached by government extension, these groups also represent a potential vehicle for broadening local impact.

The effectiveness of the full-time fuelwood and agroforestry experts provided under this project will depend to a great extent upon the MOE's willingness to work with the above groups--rather than to try to launch competing programs--and on these groups' trust of MOE's intentions.

Cookstoves

There are two quite different approaches to cookstove development and dissemination, both of which will be pursued in this project.

The first approach involves extension to stimulate local development or adaptation of owner-built cookstoves, generally mud or clay stoves designed to burn wood. In this case, it is difficult to separate development from dissemination, since potential stove users/builders (generally women) must be intimately involved in the process. A few government and non-governmental organizations--notably the Home Economics Department of the Ministry of Agriculture, the Karen Village Technology Unit (VTU), and in some areas the Peace Corps women's extension program--have supported development and adaptation of such stoves. These efforts have been carried out on a very small scale. There has been no large-scale program as, for example, AID currently is carrying out in Senegal.

There unfortunately are few national groups with a proven ability to reach rural poor women. The MOA Home Economics Branch is reasonably well staffed and trained (although its training in stove-building is limited and probably offers the best chance of success. The Women's Bureau and Community Development Division of the Ministry of Culture and Social Services have had only limited involvement in cookstoves but offer potential

extension vehicle in that they have a less formal program of extension activities. The NCCK and various denominational church groups in some cases have very effective local women's programs. In some areas the women's program of the Peace Corps has launched or supported local cookstove development programs. Finally, virtually everywhere, local women appear to have organized themselves into very effective groups, although their link to national organizations such as NCWK, Maendaleo ya Wanawake, or YWCA appears quite tenuous.

A high priority should be placed on building up and supporting these and other groups' local cookstove development/adaptation abilities, through a combination of nonformal education and participatory projects. The only training now being offered in stove building is at Egerton College and the Agriculture Institutes of Embu and Bukura. Training could also be undertaken at the Village Polytechnics and the Kenya Institute of Administration where Community Development Officers are trained. Stove building also is one of the subjects addressed by the Karen VTU, and the program there could be strengthened.

For training of trainers of Home Economics Officers, Village Polytechnic instructors, Community Development Officers, and nongovernment organizations, it may b necessary to bring in experienced short-term consultants such as the Aprovecho Institute or the Intermediate Technology Development Group. These groups also have stove testing capabilities.

The second approach is to work with local fundis to develop more efficient charcoal jikos or to develop new types of commercial wood-burning or charcoal stoves. Village Polytechnics are well-suited to encourage such development since many of their graduates become fundis and since their projects achieve local visibility. In addition, the NCCK already has a promising jiko improvement program. Finally, groups such as Partners for Productivity who specialize in assisting fundis and other small businessmen may be in a position to promote stove development.

Charcoal Production

There has been little effort to develop or promote more efficient charcoal production methods among traditional small-scale producers in Kenya. With the notable exception of individual forester's work near Nyaharuru, the little work that has been done has examined the feasibility of portable steel kilns (such as those presently manufactured in Kenya) or larger brick kilns similar to those used by EATEC.

The Forest Department in many cases licenses individuals to remove wood from gazetted forests for charcoal production. By virtue of this licensing procedure and their knowledge, field foresters should be in a good position to act as extension agents to promote more efficient charcoal production. There is, however, little indication whether they are interested in playing such a role. The next most likely extension options are Agricultural Officers and, since rural women increasingly produce charcoal, Home Economics or Community Development Officers.

So far, NGO's have not been involved in charcoal production technology, but it may be that NGO's with strong rural extension networks could play a useful role.

Community Water Supply

Numerous organizations are involved in community water supply projects, including small Harambee Groups, CARE, the Salvation Army, NCCK, and NCWK as well as the Ministry of Water Development. All of these groups could use technical advice in determining what water pumping systems to use and how to operate and maintain them. The Ministry of Water Development is particularly short of water engineers and is behind schedule in surveying potential new projects. Also, the MOWD program is oriented toward large-scale systems and they appear less interested in hydraulic rams and windmills because of their smaller pumping capabilities. Other organizations seem to be much more interested in these types of systems: a number of Catholic missions are using windmills and hydrams; CARE is experimenting with a windmill in the northern part of the country; and several Peace Corps volunteers are seeking assistance on alternative low-cost systems.

Particular emphasis should be placed on working with the MOWD to encourage it to take a second look at renewable energy water pumping systems. Training courses for District Water Engineers and technicians in the installation, operation and maintenance of these systems should be offered. Assistance should also be provided in surveying water projects to determine where renewable energy systems are applicable and in preparing proposals for EDF financing.

IV. APPLIED RESEARCH AND DEVELOPMENT

Fuelwood/Agroforestry Centers

The project contemplates six fuelwood/agroforestry research, demonstration, and extension centers. Nursery operations and extension farms and communication are major components of the centers. Both MOA and MENR already have ongoing nursery and afforestation extension programs in all or most Districts. While they currently are not nearly sufficiently extensive to satisfy all demands, they have demonstrated a capacity to expand and certainly represent a base on which to build. Particularly the MOA--with the largest farmer extension program in Africa, a network of multi-purpose tree nurseries, and a strong interest in agroforestry as a soil conservation measure--provides an excellent basis for the proposed centers.

Accordingly, it is intented that, rather than establish new operations, the MOE contract with the MOA or MENR to operate such centers with funds provided under the project. The Authority to Incur Expenditures (AIE) for each center would be held by the appropriate operations ministry. Each center would be built up from an existing nursery, using existing land, facilities, operating manpower, and supervisory structures. Additional manpower would be recruited, trained and supervised by the operating ministry, with substantial support (particularly in training and technical assistance) from the long-term forestry and agroforestry experts assigned under the project.

As in the case of extension, this project will require a substantially greater degree of interministerial cooperation than is required of most programs operating in Kenya. There are, however, examples of other cooperative programs and, in the case of the Rural Development Fund for example, of both contracting with other ministries and transferring AIE. The MOE appears willing to operate in this manner, and the appropriate organization within the Ministry of Agriculture supports the project concept and desires to participate on this basis. However, the risk of interministerial conflict, or simply inability to work effectively together, does constitute a risk for this project component.

Presuming that the ministries can work together, there is reason for optimism. Limited agroforestry extension experience in Kenya, as well as in Rwanda, Senegal, and other countries indicates that, particularly where traditional farming patterns and knowledge of indigenous species are accommodated and incorporated, acceptance of agroforestry extension will grow steadily. If the reception accorded the Ministry of Agriculture's soil conservation tree-planting program is any indication, Kenyan farmers are favorably disposed to atleast limited introduction of trees. What has happened elsewhere is that, as farmers see the results of limited tree-planting, they gradually are willing to go further. A very important point, however, is that where the two organizations are separate it generally has been agriculture, not forestry, extension officers who have succeeded in getting farmers to plant trees in the first place. The agricultural extension officer has pre-existing relationships with the farmers, he can offer advice not only on tree-planting but on the whole range of farm related activities, and with training he is in a position to advise on how to use various multi-purpose trees in ways that enhance agricultural production.

Energy Development Fund

The Energy Development Fund will require involvement of both other ministries and District or Division Development Committees to publicize availability of the Fund, encourage grant proposals, in some cases prepare proposals directly, and make funding recommendations to MOE. Again, the Rural Development Fund provides a model for such participation. The MOE and its long-term experts also will have to work closely with nongovernmental organizations both to help develop and evaluate proposals for program or project grant funding and to encourage them to stimulate local project proposals. Finally, MOE will have to cooperate with related funding sources, including the Rural Development Fund, the NCST research grant program, and the soon-to-be established Nairobi office of the VITA/AID Small Energy Grants program.

The MOE should devote a substantial portion of the long-term experts time to assisting groups to prepare sound project proposals. This assistance will pay off later in terms of the quality of the projects funded.

Grant administration is not viewed as a serious problem. The Fund is small and simple enough that the MOE, with the assistance of the Energy Planning expert, should be able to establish straightforward administration procedures and to train the Fund manager and other staff. RDF and other Kenyan fund experience is readily available. The VITA Nairobi office consti-

tutes another source of assistance, since VITA recently has had to establish its own grant procedures for AID.

V. MONITORING AND EVALUATION

Because this project is heavily oriented toward extension and institution-building and because of the degree of interministerial coordination required, monitoring will be both complicated and extremely important. It is proposed that, as interministerial agreements regarding operation of the fuelwood/agroforestry centers are being negotiated, an AID team be sent in to develop a detailed project monitoring and evaluation plan. It is mandatory that the team include a sociologist/extension expert. Also, since some monitoring function may have to be carried out by the ministries operating the centers, it is important that monitoring requirements be included in the interministerial contract.

The monitoring and evaluation plan will address not only the fuelwood/agroforestry centers but also other project components, particularly the Energy Development Fund and extension approaches supported in fuelwood/agroforestry cooking, charcoal production, water supply, and other renewable energy technology demonstrations.

The monitoring plan will provide the basis for at least annual project reviews, which should involve not only MOE but the other ministries involved. The team also will develop the plan for the final project evaluation which again should involve the other ministries.

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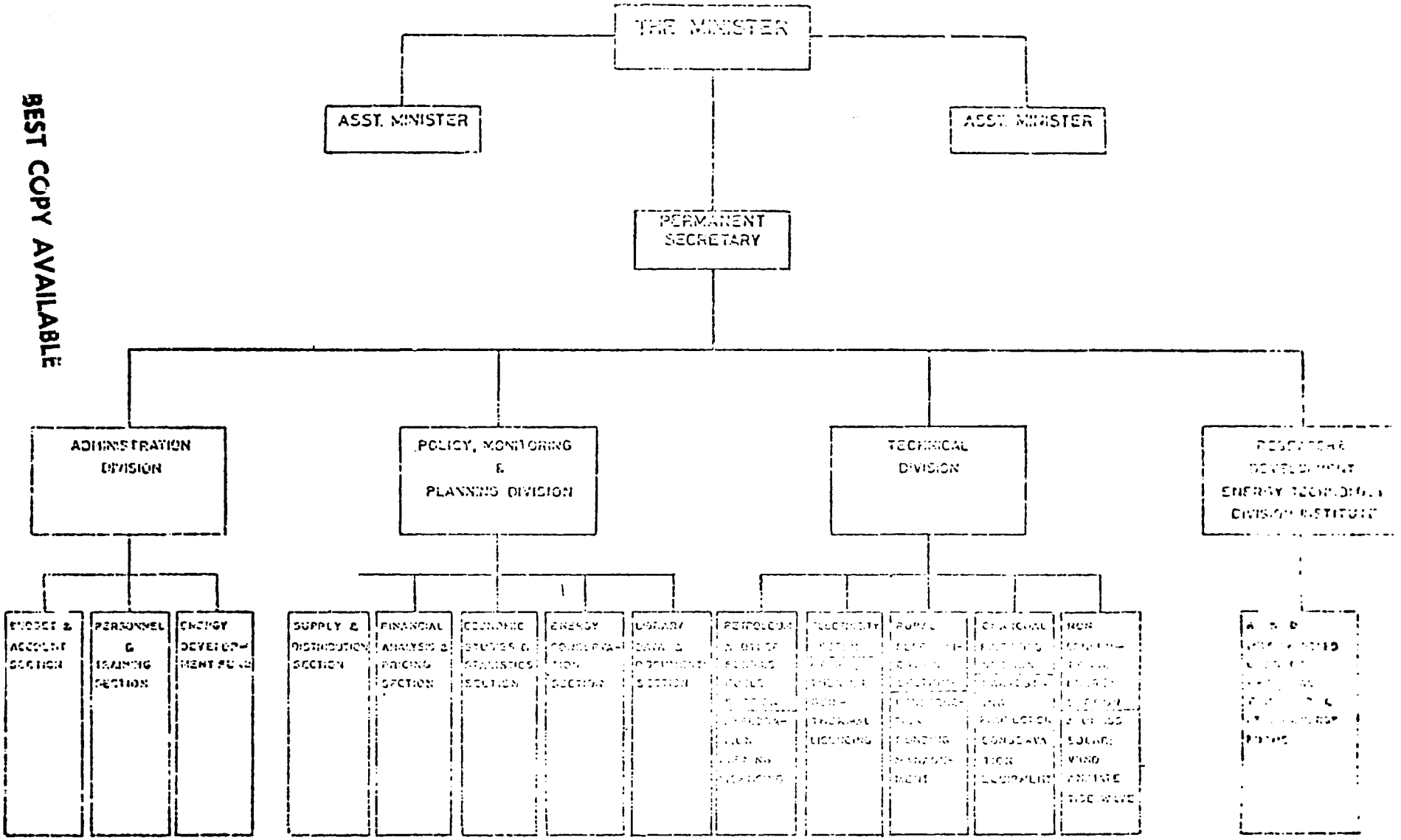
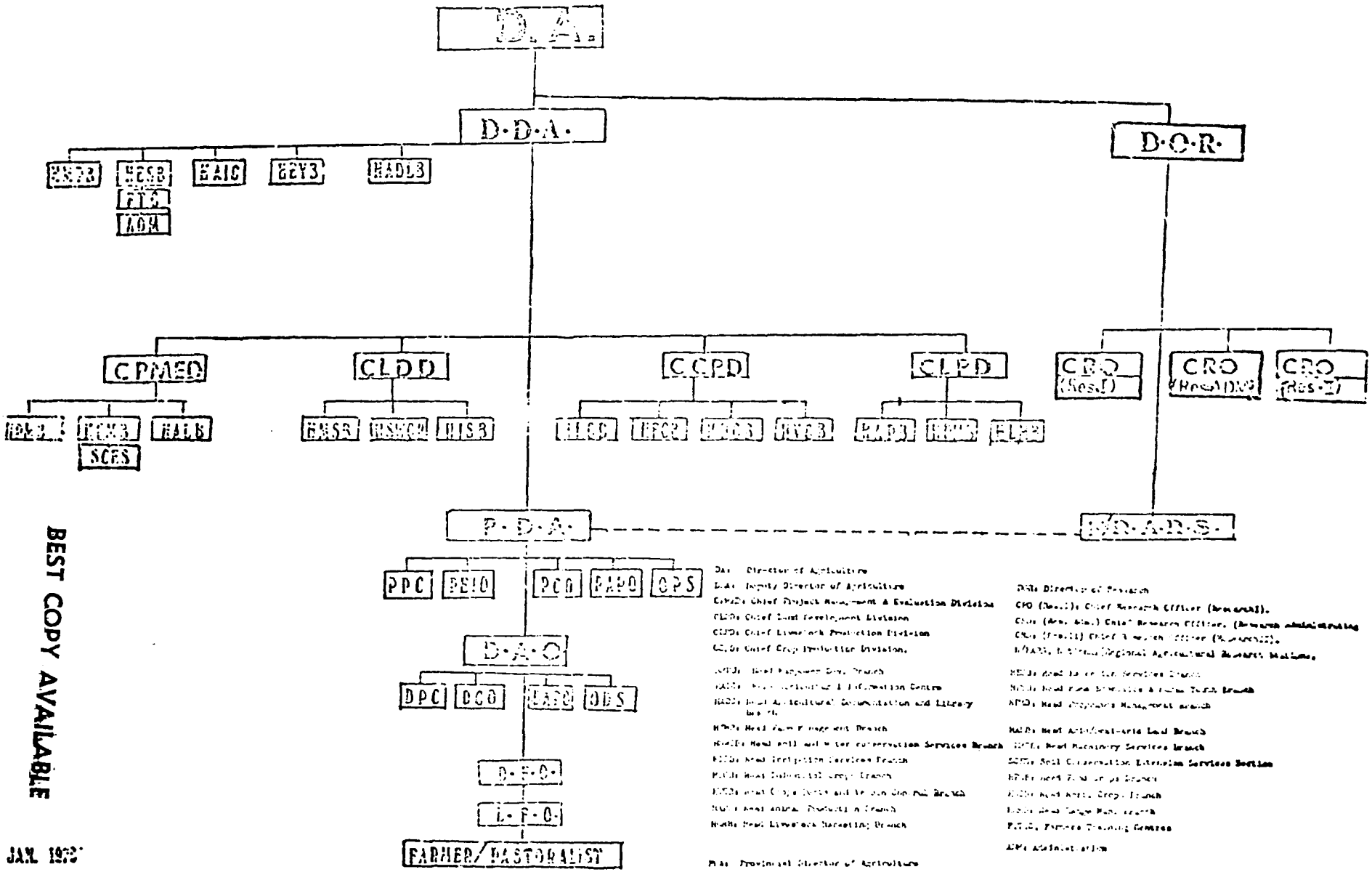


PROPOSED STRUCTURE OF THE MINISTRY OF ENERGY

MARCH 1980

ORGANIZATION OF THE DEPARTMENT OF AGRICULTURE



Dar: Director of Agriculture
D.A.: Deputy Director of Agriculture
CPMED: Chief Project Management & Evaluation Division
CLDD: Chief Land Development Division
CLPD: Chief Livestock Production Division
CCPD: Chief Crop Production Division.

Director of Research
CRO (Res.I): Chief Research Officer (Research).
CRO (Res. Admin.) Chief Research Officer. (Research administration)
CRO (Res.II) Chief Research Officer (Research).
M/D.A.R.S.: Multi-Disciplinary Agricultural Research Stations.

Pdar: Provincial Director of Agriculture
PPC: Provincial Programme Coordinator
PCO: Provincial Crops Officer
Other Other Provincial Specialists
DPC: District Programme Coordinator
DAPO: District Animal Production Officer
DEIO: District Extension Officer

PEIO: Provincial Extension & Training Officer
PAPO: Provincial Animal Prod. Officer
DCO: District Crop Officer
DAPO: District Animal Prod. Officer
DDS: District Specialists
DEIO: Extentional Extension Officer.

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ANNEX E. ENVIRONMENTAL ANALYSIS

In terms of potential environmental impact, the AID Kenya Renewable Energy Project can be divided into four major components. The first involves provision of technical assistance in collecting energy utilization and in devising policies and programs to use wood and petroleum-based energy more efficiently. Second, includes training, technical assistance, and extension assistance intended to stimulate(1) expansion of tree-planting and integration of trees into agricultural and pastoral ecosystems and (2) adoption of methods and devices to use fuelwood more efficiently, produce charcoal more efficiently, or substitute other appropriate renewable energy systems for wood or petroleum-based energy. As third component, USAID will establish a network of nursery, species research, and afforestation/ agroforestry demonstration and extension centers. The fourth component is establishment and provision of initial capital for an Energy Development Fund which will provide small grants, on a cost-sharing basis, to support renewable energy development or extension projects.

The only project component which involves direct USAID selection and financing of physical facilities is the third component--establishment of a network of nursery, species research, and afforestation/ agroforestry demonstration and extension centers. As discussed below, these centers will have a positive long-term impact on the ecology of the area. Other project components are discussed only briefly.

In compliance with the conditions set forth under Section II of the approved IEE: 1) USAID Kenya will review the environmental impact of each proposed fuelwood and agroforestry nursery, research, and extension center prior to commitment to proceed with that center; 2) as part of the criteria for Energy Development Fund financing, required that applicants (assisted by the MOE) discuss the environmental impact of proposed projects and programs ; and 3) as part of the final project evaluation, the evaluation contractor will review the environmental impact of those technologies demonstrated through the Energy Development Fund which are proposed for more widespread dissemination.

Any planning involving a change in the number of trees, the floristic composition of the tree cover or its spatial distribution must take into consideration all these functions of trees within what appropriately can be called the national ecosystem.

I. AFFORESTATION AND AGROFORESTRY

Forest Cover, Soil Erosion, and Land Productivity

The indigenous forests are valuable tools in the preservation of Kenya's ecological balance between competing land uses, as major changes in established land use patterns can have widespread consequences. In particular, the removal of the protective forest cover reduces soil

water retention capability. This in turn increases run-off and exacerbates erosion problems and reduces the regular flow of rivers which supply agricultural areas downstream.

The most serious threats to effective watershed management comes from the inconsiderate clearing of forest cover and land uses which do not conform to the physical landscape and characteristics of the watershed. These practices invariably increase the rate of run-off by exposing the soils to the natural elements. This in turn increases the momentum of rapid soil erosion processes.

There is a close relationship between the vegetative cover and the soil erosion in any watershed. A change in the vegetative cover affects soil erosion through changes in the rate of run-off. Soil erosion, in turn, affects agricultural production, the volume of water in the river, flood levels in the down-stream, the water-retaining capacity of the soil, etc.

The soil erosion due to run-off varies from place to place depending upon the vegetative cover. The higher the vegetative cover the lower the soil erosion and vice versa. A relatively small change in plant cover can result in a large difference in soil erosion.

The most serious effect of soil erosion is on land use. As a consequence of soil erosion, changes in land use become inevitable; and the changes generally are from good agricultural uses to an agricultural use with lower productivity. Occasionally, soil erosion affects land use to an extreme extent, e.g. the land becomes a complete wasteland.

Obviously there is an economic loss resulting from changes in one agricultural type to another. The main cause of this economic loss is soil erosion, and this in turn is caused by deforestation. Therefore, the economic loss resulting from changes in agricultural type can be directly linked to the effects of deforestation.

Unfortunately very few rigorous studies of the significance of preserving forest cover for such ecological needs as the maintenance of water catchment areas, the avoidance of soil erosion, and the protection of wildlife and unique ecosystems in the context of other competing claims on land use have been undertaken. A significant exception is the work of geographer/hydrologist Dr. George S. Ongweny, of the University of Nairobi. Dr. Ongweny undertook a four-year field and laboratory study of erosion and sedimentation processes associated with deforestation in the Upper Tana Catchment, which covers an area of 9250 kms^2. The study revealed an overwhelming influence of land use on surface water run-off and corresponding soil losses and sediment production. By taking into consideration various conditions of slope, vegetation density and soil types, Ongweny found

for example, that sediment production increased from about 15-20 ton/km^2/ year in areas of cultivated steep slopes and high rainfall, with limited soil conservation measures.[1] Ongweny concluded that the cutting down of trees in tropical catchments decreases the infiltration capacity of the soil and results in water, which formally flowed to the streams through the soil, traveling downslope as erosive overland flow. Thus, not only was the productive value of the steep, unprotected cultivated land in the catchment's upper reaches impared, but streamflow further down in the catchment was diminished in volume, was less reliable throughout the year, and prone to flood during times of peak rainfall. Furthermore, the acceleration of erosion speeded up the filling up of downstream reservoirs, thus curtailing their economic life. A further impact of deforestation is the reduction of wildlife habitat, which in Kenya can be economically significant due to the country's reliance on wildlife viewing, for earning foreign exchange.

Dr. Ongweny's investigation of the relationships over time between land use, hydrologic cycles, and land productivity within a major Kenyan watershed potentially could provide a basis for a method of environmental/economic analysis which could be employed fairly routinely as decision-makers are confronted with land management decisions in specific catchment areas.

Deforestation Trends in Kenya

As discussed in the body of this Project Paper, fuelwood consumption appears already to exceed the regenerative capacity of Kenya's forested areas, and rapid population growth will worsen this situation.

Since recorded production from gazetted forests supplies only an estimated 13% of total fuelwood demand, it can be inferred that residual demand is being met by private woodlots, uncontrolled forests in high potential areas, and scrubland within the lower potential areas. In addition, evidence indicates that in fact significant tree-felling has been occuring illegally within gazetted forest areas and on other publicly managed lands.

According to Kenya's Forest Department Policy, most of the indigenous forest areas are managed purely for the conservation of soil and water, based on the understanding of the delicate biotic relations existing in nature.[2] However, visual inspection suggests substantial tree-felling both purely for fuelwood (usually as feedstock to small, inefficient charcoal kilns) or as a result of land clearing for "squatter" settlements.

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[1]Onegweny, George S., Ph.D. Thesis

[2]Kiilu, J.E.I. "Forestry Resource Management in Kenya." GOK/UNEP/UNDP Project on Environment and Development, April, 1980

In several instances the removal of forest cover followed by uncontrolled grazing and cropping has already caused serious soil erosion problems, in both mountainous forest areas and the semi-arid slopes below such areas where spontaneous smallholder "squatter" settlement have resulted in wholesale clearing of large areas of natural forest.[3]

Long-Term Impact of Afforestation/Agroforestry Centers

The Proposed network of afforestation/agroforestry centers will comprise seed acquisition (both for the center's use and for use by other nurseries or, where direct sowing is feasible, by farmers or community tree planting groups), an experimental nursery to determine which species and varieties are most appropriate for the ecology of the region, a production nursery to produce seedlings of the most appropriate species and varieties, demonstration plots for both traditional afforestation and mixed tree-crop systems, and an extension group which will both work with tree-planting groups in the region and also work with extension officers and farmers themselves to promote mixed tree-crop or tree-livestock systems (agroforestry).

It is intended that these centers will both overcome important existing obstacles to expanded afforestation -- namely, availability of seeds or seedlings of appropriate species/varieties and access to extension advice regarding post-planting maintenance -- and also demonstrate and promote integration of trees into agricultural and livestock systems in ways which improve long-term soil characteristics, increase crop/livestock productivity, and provide local self-sufficiency in wood for fuel and other uses.

While the centers are expected to have limited direct impact, it is intended that they provide a basis -- in terms of knowledge of appropriate species/varieties, appropriate agroforestry techniques, and alternative extension methods -- for a greatly expanded national program. Such a program complemented by a major effort to promote more efficient fuelwood conversion and use, is necessary to avoid the extreme vegetative environmental consequences of rapid deforestation.

Possible Short-Term Impacts

Establishment of the centers conceivably could have limited short-term impacts. Land-clearing necessary to establish the center could cause local run-off and consequent soil erosion, water degradation, fugitive dust, noise, and other impacts. These impacts should be minimal in view of the small area being cleared (15-20 hectares), the priority placed on expansion of existing nurseries rather than establishment of centers from scratch, and the need to minimize such impacts in order to protect the seedlings to be grown.

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[3] Ibid.

The second possible negative impact is that some species tested will be inappropriate to the region and therefore have negative impacts on the ecology of the area. For example, some heavy water consuming varieties of Eucalyptus planted in Machakos District have been known to dry up surrounding wells. It is the purpose of the species research to identify such impacts, reject such species/varieties, and publicize such results throughout the region.

II. OTHER PROGRAM CONPONENTS

Other program conponents will have negligible direct environmental impacts and are intended to promote long-term ecological benefits.

Planning Assistance: Planning assistance to the Ministry of Energy is intended primarily to promote measures to use fuelwood and petroleum-based fuels more efficiently, thus reducing the negative environmental impacts of deforestation and of petroleum refining and combustion. Individual measures adopted by the Government of Kenya -- for exanple, incentives to promote dieselization of matatu and taxi fleets -- conceivably could entail negative environmental impacts. For this reason, long-term experts provided by USAID should be experienced in assessing the environmental, as well as the socioeconomic, impacts of policy and program alternatives.

Extension Assistance: Extension assistance will be oriented largely toward organizations promoting afforestation, agroforestry, more efficient cookstoves, and more efficient charcoal production methods. All of these are expected to have positive long-term impacts on the ecology of the region in which they are undertaken.

Extension assistance also will be provided to promote use of other appropriate renewable energy systems (for example, wind-powered water pumps) for specific applications where other forms of energy -- primarily diesel units -- were planned. Such substitution of renewable for non-renewable is expected to mave a positive environmental impact. However, the application itself -- for example, a borehole in an arid zone -- potentially could have serious negative impacts. The original decision regarding each specific application presumably already has been made and is the responsibility not of the Ministry of Energy of its experts/consultants, but of some other Ministry (e.g., for boreholes, the Water Development, Lands and Settlements, Agriculture, or Livestock Development) Nevertheless, the experts and consultants should feel obligated both to recognize such potential negative environmental impacts and, in cases where such impacts could be serious, to encourage re-examination of the original decision to proceed.

Energy Development Fund

The Fund will provide small grants, on a cost-sharing basis, for afforestation programs or for the development and dissemination of specific renewable energy systems. Some such systems conceivably could have a negative environmental impact. However, the low ceiling ($10,000) for each project grant, the guidelines regarding technologies to be preferred (small-scale systems with low capital investment) and the demonstration nature of the projects funded make it unlikely that any project could have a substantial local impact.

Nonetheless, in order to receive EDF financing applicants will be required to briefly discuss the environmental impact of their proposals. They should be assisted in this effort by MOE, and the project experts. Where a given technology conceivably could have an important negative environmental impact is in the decision to go from demonstration to national or regional dissemination/extension. Thus, as part of its evaluation of the outline Project, the evaluation contractor should review the potential environmental impacts of those EDF-supported technologies which the Government of Kenya has selected or is considering selecting for broad dissemination.

IMPACT IDENTIFICATION AND EVALUATION FORM

Impact Areas and Sub-areas	Impact Identification and Evaluation
A. LAND USE	
1. Changing the character of the land through:	
a. Increasing the population.....	N
b. Extracting natural resources....	P
c. Land clearing....	L
d. Changing soil character....	P
2. Altering natural defenses....	P
3. Foreclosing important uses....	N
4. Jeopardizing man or his works....	N
5. Other factors....	N
B. WATER QUALITY	
1. Physical state of water....	L
2. Chemical and biological states....	N
3. Ecological balance....	P
4. Other factors....	N
C. ATMOSPHERIC	
1. Air additives....	N
2. Air pollution....	N
3. Noise pollution....	N
4. Other factors....	N
D. NATURAL RESOURCES	
1. Diversion, altered use of water....	P
2. Irreversible, inefficient commitments....	N
3. Other factors....	N

E. CULTURAL

1.	Altering physical symbols....	N
2.	Dilution of cultural traditions....	N
3.	Other factors....	N

F. SOCIOECONOMIC

1.	Changes in economic/employment patterns....	L
2.	Changes in population....	N
3.	Changes in cultural patterns....	L
4.	Other factors....	N

G. HEALTH

1.	Changing a natural envirionment....	N
2.	Eliminating an econsystem element....	N
3.	Other factors....	N

H. GENERAL

1.	International impacts....	N
2.	Controversial impacts....	N
3.	Larger program impacts....	N
4.	Larger program impacts....	N
5.	Other factors....	N

I. OTHER POSSIBLE IMPACTS (not listed above).... N

N- No environmental impact

M- Moderate envirionmental impact

U- Unknown environmental impact

L- Little environmental impact

H -High environmental impact

P- Positive environmental impact

INITIAL ENVIRONMENTAL EXAMINATION

Project Location:	Kenya
Project Title:	Renewal Energy Development Project (615-02(
Funding:	Three year (81-83)
Life of Project:	3 years
IEE Prepared By:	Satish P. Shah, General Engineering Office
	USAID/KENYA
Date:	February 15, 1980
Recommendation:	Negative Determination
Concurrence:	Date: 3/20/

Glenwood P. Roane
Director, USAID/Kenya

Assistant Administrator's Decision:

APPROVED: _____

DISAPPROVED: _____

DATE: _____

I. Project Description:

The Renewable Energy Development Project provides assistance to the Ministry of Energy (MOE), and to a lesser extent to the Ministry of Environment and National Resources, to permit these bodies to address more effectively questions of energy policy and development and application of renewal and non-conventional energy sources for rural areas of Kenya. Project elements include:

(i) Initial planning and surveys;

(ii) Institutional development and training;

(iii) Applied research and demonstration of renewable energy sources such as village/household level reforestation and agroforestry; wood and charcoal stoves; charcoal kilns; biomass; solar energy devices for heating and crop drying; water pumping systems; food processing systems and small-scale electricity for clinics, school and other rural services; and

(iv) Monitoring and Evaluation.

II. Identification of Impacts:

Elements (i) and (ii) of the project, which include training and technical assistance in developing GOK's capability to formulate energy planning and policy, primarily for rural areas, do not raise environmental issues.

This negative determination applies only to laboratory development of renewable energy devices. If it is determined that any device is suitable for replication and village level testing, the possible environmental effect of such devices will be carefully assessed and no devices will be tested in villages unless such assessments are positive. During the testing phase of such devices, the environmental effects caused by the devices shall be closely monitored and documented. This information will be used to determine the adviseability of widespread replication. If adverse effects are detected during the monitoring phase, measures to mitigate such effects will be developed as a part of the testing procedure. Under no circumstances will hydropower subprojects be developed in advance of an environmental assessment.

III. Recommendation:

For the above reasons, a negative determination is recommended.

ANNEX F:

GOK AND NON-GOVERNMENTAL ORGANIZATIONS

WITH PRESENT OR POTENTIAL PROJECT-RELATED PROGRAMS

Ministry of Energy

The Ministry of Energy was created by Presidential Circular No. 1/80 (8 January, 1980) with the following function: "Energy Policy and Development Electric Power Development, Oil and Other Fossil Fuels, and Exploitation and Exploitation of Non-Conventional Energy Sources-Wind, Biogas, Solar, Geothermal Woodfuel etc." The Ministry has an authorized 1980/81 Budget personnel ceiling of 146, but the total staff on board as of August, 1980 was below 100.

The Ministry is entirely a headquarters organization, with no staff at the District level or below. It thus must draw upon other Ministries for field extension support.

MOE is organized into four divisions--Policy, Monitoring, and Planning; Technical; Administration; and Research and Development. The R&D Division exists on paper only, as a home for a contemplated quasi-independent Energy Technology Institute. The other three divisions, which are staffed to varying degrees, all will be involved in this project: The Energy Development Fund has been assigned to the Administrative Division; the long-term Energy Planning and Conservation Expert and related consultants are to work under the Policy, Monitoring and Planning Division; and the other long-term experts and consultants will be housed in the Charcoal/Firewood Section or Non-Conventional Energy Section of the Technical Division.

Ministry of Environment and Natural Resources

Forest Department

The Forest Department is responsible for management of the GOK's gazetted forests (roughly 1.7 million hectares) including both indigenous forests and roughly 130,000 of industrial plantations. The Forest Department also operates the Rural Afforestation Extension Scheme (RAES) started in 1977, which includes one extension officer and at least one nursery per district.

The Department has a professional and paraprofessional staff of roughly 1800--including forestry graduates, intermediate staff (foresters and senior foresters), rangers, forest guards, and others--and an authorized labor force of around 10,000 persons.

Department staff receives most of its training at Forestry Training College at Londiani. In addition, while most graduate foresters were educated outside Kenya, the Department is beginning to recruit graduates from the recently-formed University of Nairobi Forestry Program.

The Forest Department has been criticized for concentrating too much research and operational effort on highland species for production of saw timber and pulpwood. The RAES is the Department response to such critcism. While the RAES is too new to be evaluated fairly its field officers appear to be trying to establish an effective program, but facing serious budget constraints, shortages of appropriate seeds and other problems.

This project potentially will involve most operations of the Forest Department including RAES (rural afforestation nurseries and extension and possibly improved charcoal production methods), conservators of gazetted forests (woodfuel management and improved charcoal production), the Conservator of Reasearch (as the logical coordinator and clearing-house for species research results), and the Forestry College (extension training). The good-will and cooperation of the Department thus is important to the success of the project.

National Environmental Secretariat

This organization is responsible for advising all governemnt ministries on the role of environmental resources in Kenya's development. It plays a coordinating role for non-governmental organization tree-planting activities. The Secretariat has recently stressed the concept of "integrated" development planning particularly in the arid and semi-arid lands of Kenya. The National Land Use Commision is part of the NES.

Ministry of Agriculture

A number of the programs of the Ministry of Agriculture are directly related to the project, including soil conservation, home economics, and small-scale irrigation. In addition many of its training and research activities could be modified to incorporate renewable energy-related components, such as Egerton College, the Agricultural Institutes, farmer training centers, and agricultural research stations. A few of these programs are discussed below:

Land Development Division-Soil and Water Conservation Services Board (SWCSB)

The SWCSB has been working on tree resource applications to soil resource conservation. Simple handbooks and training manuals have been produced for the small farmer to help conserve soils particularly on steep slopes. Approximately twenty-five nurseries have been established to provide seedlings for on-farm utility. Pine, *Eucalyptus* and occasionally *Acacia* are the species normally propagated. Results of conservation extension information vary depending upon socio-economic factors within each district. Exceptionally well-managed small and large farms can be seen throughout the country. There has been some limited coordination between activities of the SWCSB and the Forest Department.

It is essential that the project draw on the experience of the SWCSB and work through its already existing nurseries to the extent possible.

Land Development Division-Small-Scale Irrigation Unit.

The Unit is experimenting with renewable energy water pumping technologies in small irrigation schemes.

Agriculture Extension Service

MOA has over 10,000 extension agents at the District Division, and Location levels. These officers either have a three-year diploma from Egerton College or a two-year certificate from Embu or Bukura Agricultural Institutes

Home Economics and Youth Services Branch*

This section was initiated in 1963. Its focus is broad including agriculture, nutrition, income-generating activities, labor-saving technologies and domestic skills. Beginning in 1968 women were admitted to the Kenya agricultural training institutes, including the three-year diploma course at Egerton and two-year certificate level courses at Embu and Bukura Agricultural Institutes. The curriculum of home economics training is devoted 60% to agriculture and 40% to home economics. Home economists in Kenya number approximately 325 including teaching management and contact staff (total MOA contact staff number over 10,000). Those at the District Divisional levels receive training at Egerton or Agricultural Institute. A number of those below the division level receive only a few weeks of formal training. The Home Economics staff works with Farmer Training Centers, rural women's groups and individual rural families, but group approaches have been found to be most effective, due to resource and staff scarcities.

In addition to limited training in alternative cooking technologies, at Egerton and the Agricultural Institutes, some home economics officers have visited the Karen Village Technology Unit. Once they are placed in the field, however, they have limited access to technical assistance, materials (and transprotation) to carry out this activity.

Miss Wagema, the Branch Head, would like to establish small demonstration cooking technology demonstration units in each of the Farmer Training Centers, as well as at the various Agricultural Shows. She may be receiving some assistance in this effort from the German aid agency.

In addition, the U.S. Peace Corps, USAID and MOA have begun a five-year, $175,000 project to enhance the quantity and quality of rural extension services available to women. The project is providing 21 PCV-Kenya counterpart teams with their own transportation, in-service training, technical materials, and technical assistance in monitoring

* This information was largely obtained from "Rural Women's Extension Service", an AID Sub-project (689-0388.13)

and evaluation.

Home Economics officers could play a central role in owner-built mud (clay) stove development and dissemination if they had more training and technical assistance.

Ministry of Economic Planning and Development

Functions of this Ministry include national development planning, assistance to rural planning efforts, and the Central Bureau of Statistics. The Rural Planning Section of the MEPD is working to decentralize development planning through the training of district development teams, assisting in the formulation of district development plans and financing of local projects through the Rural Development Fund. The Fund represents about 1% of the total national budget. District Development Officers have been given the "Authority to Incur Expenditures" Funding applications are reviewed by the District Development Committees before final approval by the MEPD.

The Central Bureau of Statistics undertakes all statistical work for the government including data collection and storage analysis and interpretation. As part of its Integrated Rural Survey, CBS is working on a household energy consumption survey.

The MEPD could play an important role in the project by coordinating energy conservation planning and data gathering and helping to involve district level planning personnel in the project.

The National Council on Science and Technology

The NCST is responsible for the development of science and technology for Kenya. It approves and coordinates all public sector research activities and operates a small research fund.

Ministry of Livestock Development

This recently created Ministry is responsible for animal industry, production and marketing, range development and management, etc. MOE should work closely with MLD to promote the incorporation of combined fuelwood/fodder trees in livestock programs in the arid and semi-arid zones.

Ministry of Culture and Social Services

Women's Division

The Women's Division was created in 1975 to increase awareness and disseminate information on the position and needs of women. Other activities include, training, data collection and support to women's

groups through community development officers. In addition to its handicrafts and small business projects, the Division initiated an appropriate technology project in 1977. Over 30 community development officers were trained at the Karen VTU. They have discussed the technologies with women's groups and 35 groups have asked for technologies to try out. The materials are now being ordered.

The Division has also established a technical advisory committee composed of representatives from several government ministries and non-governmental organizations. It receives support from a number of foreign donors including UNICEF, DANIDA and NORAD.

The Division could also play a rôle in mud/clay stove development and dissemination through Community Development Officers and Assistants.

Community Development Division

Community Development Division programs include assistance to Harmabee self-help projects, family life training centers (primarily nutrition education), craft development, women's programs and family planning activities. It has a large field staff consisting of District level Community Development Officers, which are trained at Kenya Institute of Administration, and Community Development Assistants which are employed by the District Development Communitées and generally receive limited in-service training. This Division could potentially be involved in community tree-planting activities and cookstove introduction.

Ministry of Labor

Karen Village Technology Unit

The VTU was created in 1976 by UNICEF and the Ministry of Housing and Social Services (since reorganized) to provide a focal point for the development and demonstration of appropriate technologies to promote better family nutrition. It was placed in Karen, so that the village polytechnic instructors and staff (trained at the Karen Center for Research and Training) could benefit from it.

The VTU is now receiving several thousand visitors annually, primarily teachers, students, people from non-governmental development organizations and government ministries. The VTU provides training courses for VP instructors, and other groups requesting training. The courses and workshops are often on-site. Several similar, but smaller technology units have been established at the Bukura and Embu Institutes of Agriculture, the Nakuru Agricultural Showground, the Ahero Family Life Training Center and by the Development Coordinator of the Diocese of Kitui.

The technologies have received limited acceptance by the staffs own admission. One reason is that people trained there do not have the seed money to get started. The VTU would like to become involved in extension but has limited funding and staff. Another constraint is that the VTU and the Village Polytechnics were recently transferred from the Ministry of Social Services to the Ministry of Labor and it is uncertain if their functions will be modified and whether they will remain under this Ministry.

TRAINING INSTITUTIONS

The network of training institutions in Kenya is extensive and complex. There are over 2000 government and non-government institutions, more than 200 of which are operated by the government to train its civil servants, teachers extension workers, and field technicians. University education includes the University of Nairobi and Kenyatta University College. There are also several teachers colleges. In-service training is provided by the various Ministries and also at the Maseno and Mombasa Government Training Institutes and the Kenya Institute of Administration. Pre-service training for different fields is as follows:

Agriculture Training Institutions include the University of Nairobi, Faculty of Agriculture which has B.Sc. and some MSc. programs, Egerton College which gives a three-year diploma and the Embu and Bukura Agricultural Institutes giving two-year certificates. Graduates of these institutes generally serve as the extension and home economics officers at the location level, graduates of Egerton serve at the in-supervisory positions at the Divisional level and university graduates serve at the District level and above. In addition, there are:

Twenty-five Farmer Training Centers in the major agricultural districts offering one-week courses to farmers in a variety of agriculture-related subjects. The Centers have dormitories, teaching facilities and often small test farms. They charge a small fee for the courses, thus it is generally the aboveaverage farmer who has the time and money to attend the courses.

Forestry Training Institutes include the Forestry Training School at Londiani which offers programs for foresters, forest assistants and forest guards and the University of Nairobi, Department of Forestry, the Department graduated its first class of eight in 1979, all of which are now employed by the Forest Department. Another 15 will graduate this year.

Harambee Institutes of Technology institutes provide vocational training for secondary school levels in mechanical, electrical, and agricultural engineering, building trades, food processing, irrigation, and business studies. Fifteen have been proposed and 12 are operational. Many of them are well-funded and well-equipped.

Village Polytechnics were established in 1966 to provide technical training to Form 1-4 levels to enable them to become self-employed in their own areas. Courses include masonry, carpentry, metal working, etc. The courses include some classroom activities, but primarily involve "on the job"training. Tailoring and home economics training are offered but the materials and classroom space devoted to these activities is limited. The number of femalestudents appears to be considerably less than male students. The government is now assisting over 200 VP's while voluntary agencies and local government are assisting another 150. They are run by local management committees and staffed by instructorswho are trained at the Center for Research and Training (CRT) in Karen. Many VP's are constrained by a lack of funds for materials.

Non-Government Organizations

National Christian Council of Kenya (NCCK)

NCCK is an umbrella organization for about 40 churches/organizations. It serves as a conduit between the churches and international funding agencies. As well as provides technical, managerial, planning and training projects and services of its own. It employs over 100 people many outside of Nairobi, and has an annual budget of approximately 22 million Shillings. NCCK projects with relevance to renewable energy use include afforestation, cottage industries (including bakeries, and charcoal and firewood selling) urban community improvement, adult education, village polytechnics, rural training centers, inproved animal power and small-holder irrigation schemes.

NCCK's tree seed distribution program was started in 1977, to spread seeds and knowledge of trees useful for dry areas. Assistance was provided to organizations such as church groups, Village polytechnics and other rural development projects and a seed bank was established. NCCK estimated in 1979 that over 50,000 trees were growing in dry areas as a result of the project, and that demand for seeds continued to grow.

NCCK appears to have good extension capabilities and could potentially play an important role in may or all of the project's components.

Young Women's Christian Association (YWCA)

The YWCA has a membership of 3000 and 4 major branches in Kenya, Meru, Mombasa, Kisumu and Nairobi. Its activities include providing courses to and assisting women's groups in raising money, running youth hostels for income generation, and serving as a community center for a number of different activities. In April, the Nairobi YMCA hosted an appropriate technology workshop for all African Y's, which included a trip to the Karen VTU. The Kenya Y is selecting technologies from the VTU and areas for demonstration with training provided by the VTU. The YMCA has a national staff of 5, a Nairobi Branch Staff of around and small staffs, (primarily volunteer)

at the other branches. They work closely with government ministries, such as the Ministry of Culture and Social Services, in implementing projects.

In those areas where it has strong branches, the Y could become involved in both wood and charcoal stove development, dissemination and training.

National Council of Women of Kenya (NCWK)

NCWK was formed in 1964 as a co-ordinating body for women's organizations of which there are 41 affiliated and associate member groups. The Council serves as an information dissemination source on women's issues, assists members in obtaining funding for their projects, and has some development projects of its own. Its two most notable programs are community water supply (in cooperation with UNICEF, CARE, ect.) and "Save the Land Harambee" tree planting on public lands. NCWK has a very small, primarily volunteer, staff in Nairobi. It works through Government ministries at all levels in implementing its projects. With additional assistance the NCWK could expand its tree-planting and public education activities.

Maendaleo Ya Wanawake

This is a national women's organization formed in the early 1950's with a membership of 100,000 individual and group members. It is working to build up its field staff and now has 18 representatives at the Provincial level and one representative in each District(voluntary). Its development projects include a maternal and child health program covering four provinces in cooperation with Pathfinder (financed by Federation of Women's Institutes of Canada ($33,000 last 2-3 years); and a training program consisting of the training of women trainers (voluntary) in nutrition, and economic self-reliance and income generation.

The group works through Government ministries in implementing its projects. However, it believes it could run its own projects if it had the funding to hire some staff.

If Maendaleo builds up its extension capabilities, it could play a potential role in community water and stove projects.

Salvation Army and other Church Organizations

The Salvation Army has over 200 churches in Kenya and officers at the national district divisional and church level. Its churches sponsor a number of activities such as education, women's and youth activities. In addition, they sponsor rural development projects including support to Village Polytechnics, and 4 K clubs. The organization believes its strong point is its ability to reach large numbers of people through church activities.

It could play a role in wood and charcoal stove promotion, particularly through women's groups and village polytechnics and possibly initiate tree planting activities through 4-K clubs.

Numerous churches are active in Kenya and seem to be divided geographically with the Methodist church strong in Meru, the Catholic church in Embu and Meru, the Quaker meeting in the West, the Anglican Church (C.P.K.) in Embu and the West.

Churches play an important role in bringing people together for educational programs, church upkeep, social and other group activities involving women's groups and youths. Many of the churches run hospitals, clinics and schools.

In addition, some church organizations finance and manage development projects. The C.P.K, for example, placed a Development Secretary in Embu District last year. He acts as a conduit between donor funding and local development projects such as a maternal and child health program. Many other churches also have Field Development Coordinators.

Because of their ability to reach even the poorest people, the churches should be encouraged to participate in both operational and educational aspects of the project.

CARE

CARE is engaged in long-term community development program in cooperation with the Ministry of Culture and Social Services to assist rural communities constructing basic facilities necessary for development. It is also engaged in a long-term water development program in cooperation with Ministries of Water Development and Social Services. From 1975 - 1977 they assisted 49 rural communities with materials for self-help water projects (partial USAID financing). During 1978, 43 other projects were initiated. CARE's major role is to act as a conduit between the community and the MWD. Its engineer and program coordinator inspect each request before funding and sometimes sometimes provide additional supervision of construction of system.

CARE could become involved in promoting and demonstrating community water pumping systems.

The Peace Corps

The Peace Corps has been active in Kenya for many years. At present there are approximately 250 volunteers throughout the country involved in a variety of activities including rural women's extension, agriculture extension, water development and teaching. According to the Peace Corps Mission Director,many volunteers would be interested in helping to establish rural nurseries and assisting in extending technical information on tree uses and their potential to rural farms and communities.

A number of volunteers have submitted proposals to the AID Improved Rural Technology Project to obtain funding for such projects as small-scale water pumping for irrigation and community water using windmills and hand-pumps.

Peace Corps volunteers could play an important role in several aspects of the project, however, it is important that the Y work within an existing organization so as to institutionalize their activities.

Freedom From Hunger

Similar to CARE, it has projects in nutrition, education, tree planting, village polytechnics, youth development, and crafts.

Technoserve

Provides technical services to local enterprises through management assistance and training, transfer of technology and assistance in locating capital funds. Projects in Kenya generally involve assistance to cooperative credit and savings organizations, e.g. Harambee Cooperative Savings and Credit Society, Drumvale Farmers Cooperative Society Ltd. More research should be done on Technoservices' interests amd capabilities before soliciting their involvement in the project.

Partnership for Productivity

PFP is a private voluntary organization whose main purpose is to improve and expand rural small-scale Kenyan owned and managed businesses and manufacturing enterprises. This is done through two prototype projects: (1) The Rural Enterprise Extension Service provides "on-site" visiting of a wide variety of rural enterprises as a supplement to classroom training; (2) the Rural Market Loan Scheme is a credit scheme to provide small enterpreneurs, who would not otherwise qualify for a commercial loan, experience in receiving, utilizing and repaying borrowed money. (They have staff of extension workers and consultants in Kenya.)

PFP has a USAID Operational Program Grant which may be extended. It has proposed a women in development project to AID, consisting of hiring a cadre of women consultants and extension workers, working with women entrepreneurs, assisting women's groups to lobby with GOK ministries and parastatals, etc.

Institute for Cultural Affairs

ICA is a multinational, private voluntary organization with a staff of approximately 20 "internationals" and 200 Kenyans (many voluntary) in Kenya. Its major activity is to stimulate village development through a process of "village animation" where by a village meeting is held and a few villagers are selected to be trained at the ICA Human Development Training Institute. Training covers such areas as identifying human needs, utilizing local resources, government services and appropriate technology in resolving problems and working communally. The trained people are then sent to a village to work with the villagers in identifying and undertaking development projects. They have done this in ten villages, and are now expanding to about 5 others and hope to increase the number each year.

International Council for Research on Agroforestry

ICRAF is an autonomous, non-profit international institute with equal representation from the developing and developed world which was established in 1978. Its objective is to improve the nutritional, economic and social well-being of people in developing countries through the promotion of agroforestry systems. It has sponsored a number of seminars, and workshops on agroforestry, responded to requests for information, developed a 35-hour lecture outline for a general undergraduate course in agroforestry and prepared project proposals in 7 countries, including one in cooperation with the University of Nairobi.

ICRAF could potentially become involved in curriculum development, training and other aspects of the agroforestry component.

Baobab Farms Limited

This private organization is responsible for land reclamation activities associated with the Bamburi Cement Company in Mombasa. The limestone mining process leaves a landscape composed entirely of steril (corral) rock fragments. Using ecological principles and innovative management techniques, Baobab Farms have reproduced a landscape more productive than surrounding degraded pastures.

Many liguminous tree species and other tree varieties have been tested and introduced to their reforestation programs. Baobab Farms could be contracted to supply seeds of selected tree species, particularly the arid and semi-arid varieties for Governmental and non-governmental organizations recommended for involvement in this program. Training programs in tree selection, nursery practices and establishment should also be considered in addition to seed production.

Aprovecho Institute

The Aprovecho Institute has extensive experience in West Africa, Latin America and Asia in cookstove development programs. Aprovecho has an excellent record of cooperating with local government agencies, private voluntary organizations and rural people themselves, in the participatory stove design and construction process. An organization of this nature could train Peace Corps volunteers prior to or during their tenure in Kenya, field workers in community organizations such as the NCCK, Home Economic officers and other potential stove building trainers.

Intermediate Technology Development Group

ITDG has submitted a cookstove research and development proposal to the Karen Village Technology Unit. They are seeking to develop working relationship with a Kenyan collaborating organization willing to commit at least two counterparts and a physical design and testing facility,

ITDG's proposal includes survey, communication, testing and outreach components. The cost of this program would be primarily for two Kenya staff members, test equipment and traveling and material cost during survey field testing and extension phases. ITDG's technical assistance to the programs would also be substantial.

LOGICAL FRAMEWORK

Renewable Energy Development: Project 615-0205 Life of Project: FY81-86 Date: August, 1981 Annex G

Narrative Summary	Objectively verifiable indicators	Means of verification	Important assumptions
A. Goal level **Reduced adverse impact of fossil fuel imports on Kenya's balance of payments and progress toward achievement of a balance in wood fuel supply and demand.**	1. Reduced dependency on imported fuels for industry and transportation. 2. Universal deployment of petroleum fuel conservation measures in the modern sector and wood and charcoal conservation among the rural and urban poor. 3. Increased woodfuel production. 4. Increased use of renewable energy.	Surveys, import statistics Policy document, observation, surveys Survey, Remote sensing, ground checks Survey, site visits	1. Energy conservation and energy programs to exploit renewable energy resources are a high GOK priority that prevails throughout government programs.
B. Purpose level **To establish a capability in the MOE to formulate policy and to plan, oversee implementation of, provide technical assistance on, monitor and evaluate renewable energy programs and energy conservation measures in all sectors of the economy.**	1. Identification and implementation of measures to improve the efficiency of use of petroleum and wood fuels. 2. MOE providing energy expertise to support other govt. and private entities. 3. MOE providing nursery/extension centers as agents for technology transfer on afforestation, forest management and agroforestry techniques appropriate to each ecological zone. 4. Effective use of Energy Development Fund to promote new ideas, enhance existing technologies and to institutionalize energy saving and renewable resource tech. in Kenya. 5. Capability in systematically evaluating energy technologies and extension methods to ensure that lessons learned are integrated into new and existing programs. 6. Formulation and establishment of national energy policy.	Policy documents Observation, inter-ministerial committee observation, annual reports Annual reports, monitoring, site visits monitoring and evaluation plan formulated, MOE staff trained Policy documents	1. The GOK is able to successfully marshall the cooperation and collaboration of various Ministries, parastatal and private entities to effectively implement its energy policies and programs.

Narrative summary	Objectively verifiable indicators	Means of verification	Important assumptions
G. Output level			
1. 15 trained energy planning, conservation and renewable energy staff for MOE	1. Training courses attended.	Inspect certificates	1. MOE is fully staffed and operational within 12 month of approval of project.
2. Up to 6 nursery/extension centers established in conjunction with existing nurseries.	2. Centers established.	Site visit	2. U.S. contract personnel on board by June 1981.
3. Info. and technologies in afforestation, forest management and agroforestry disseminated.	3. Trees planted	Informal field survey, records of nurseries.	3. Contract arrangements made with other Ministries by August; 1981.
4. Completed energy consumption & production surveys in industry, transportation, households.	4. Surveys completed and analyzed.	Read reports	4. Organizations and groups apply for Energy Developmen Funding.
5. Analyses of energy resources, pricing, marketing, distribution completed.	5. Analyses completed.	Read analyses	
6. An expanded renewable energy curriculum in Kenyan training institutions, trained faculty assigned thereto, teaching materials printed.	6. Curriculum materials printed, training courses held, teachers assigned.	See materials,	
7. Established Energy Data Bank and Library.	7. Facilities established, librarian trained.	Visit	
8. Demonstration activities in: -agroforestry -woodlot management -improved cooking devices -improved charcoal production techniques -other renewable energy tech.	8. Trees planted, improved cooking devices, charcoal production methods, and other technologies being used.	Monitoring and evaluation, site visits.	
9. Evaluations of the effectiveness of various technology demonstrations and extension methods.	9. Evaluation reports, process documentation, annual reports.	Read reports	
10. Established Energy Development Fund to support programs and demonstrations listed above.	10. Charter completed, applications received, loans and grants made.	Inspect charter, applications, loan/grant papers.	
11. Feasibility study on metal cookstoves for urban use.	11. Study completed.	Read study	
12. Completed informal survey of local nursery and tree planting activities.	12. Report produced.	Read report.	

C. Output level (continued)			
13. Completed informal survey of cookstoves use and cooking methods, jiko and pottery makers, and informal charcoal production.	13. Report produced	13. Read report	
14. Completed informal survey of operation and maintenance experience with windpumps and hydraulic rams.	14. Report produced	14. Read report	
15. Developed material for and conducted workshops on the various technologies.	15. Materials printed, workshops held.	15. Inspect materials, attend workshops	
16. Other informational material developed.	16. Materials printed and available	16. Inspect materials.	
D. Input level 1. Technical assistance a. Energy planner/project manager (3 years) b. Forestry/extension expert (3 years) c. Agroforestry expert (3 yrs.) d. Wood/charcoal expert (18 mo.) e. Renewable energy water pumping expert (18 mo.) f. Short term consultants: -implmentation planning for fuelwood/agroforestry centers -Energy Data Bank and Library -Energy policy, information systems, conservation -curriculum development, training, extension	1. Contract signed. 2. People hired. 3. Scopes of work, duties and qualifications prepared.	1. Examine contract 2. Examine 3. "	1. Project authorized.
2. Training a. in use of AL-EDIS system b. energy planning and renewable energy c. extension officers for centers, other extension officers, field staff d. informal workshops e. observational tour training	1. Courses attended 2. Workshops held 3. Trips taken	1. Inspect certificates 2. Visit workshops	

3. <u>Commodities</u> a. Books, periodicals and library equipment b. curriculum and other educational materials c. three vehicles d. monitoring and testing equipment e. 6 pick-up trucks f. 1 station wagon g. 1 Land Rover h. 6 tractors with trailers i. 2 disc ploughs j. 2 disc harrows k. 1 subsoiler l. fencing material m. tree seeds n. survey equipment o. tools p. office supplies q. photographic supplies	1. Materials delivered	1. Inspect purchase orders.

ANNEX H. ENERGY DEVELOPMENT FUND

The project will provide consulting assistance and initial capital necessary to establish an Energy Development Fund. The purpose of the Fund will be to promote development and dissemination of innovative renewable energy technologies and extension approaches, with emphasis on those technologies and extension approaches likely to benefit AID's target population groups, as defined in the Country Development Strategy Statement (CDSS).

Of the initial capital for the Fund provided under this project, one-half is to be allocated to soft-loans or grants to governmental or non-governmental organizations to support broad renewable energy demonstration or extension programs. The other half will be used for soft-loans or grants to governmental or non-governmental organizations to finance specific demonstration projects. Both types of loans/grants will be provided on a cost-sharing basis, with the recipient expected to provide a minimum 25% matching contribution to the program or project.

I. General Grant Criteria

1. Technologies

For both types of loans/grants, renewable energy technologies directly benefitting AID target population groups are to be given priority and will account for a minimum 75% of grant funds awarded. These technologies include:

- Community afforestation/reforestation;
- Small holder afforestation or agroforestry (including integration of trees into cropfarming and/or livestock systems);
- Improved wood or charcoal stoves (including owner-built and commercial mud/clay, metal, and pottery stoves);
- Solar warmers (e.g. hay-box cookers);
- Improved small-scale charcoal production methods;
- Use of wind or water power for small-scale community water supply systems serving AID target groups;
- Use of wind or water power for small-scale informal sector industry (e.g. posho mills);
- Solar drying of cash crops or foodstuffs raised (but not necessarily processed) by small holders;
- Low-cost human or animal-powered equipment for small holder or rural village use (e.g., hand or pedal powered grain grinding or water pumping);
- Low-cost methods for heating/cooling traditional urban or rural dwellings (e.g., improved thatch insulation);
- Low-cost heating/sterilizing or chilling devices for rural health centers (e.g., solar water boilers); and
- Other technologies which can be shown to be useful to, affordable by, and appropriate to the socio-economic characteristics of any of the target groups.

2. Organizations

Soft-loans or grants under either component may be made only to officially constituted organizations, including GOK, NGO's, registered Harambee groups, and private sector corporations, partnerships or sole proprietorship. In addition, the MOE may provide loans from the Fund to the Agriculture Finance Corporation (AFC), Kenya Industrial Estates (KIE), or other official financier agencies who may re-lend to private farmers, private businessmen, or other qualified individuals.

3. Economics

An applicant for either type of loan/grant must show that the technology demonstrated or disseminated can be produced and delivered within a cost range which is likely to make it economically attractive to the potential users. This economic analysis may take the form of a simple payback or discounted cash flow analysis or a cost comparison versus whatever system(s) would be displaced by the technology or technologies being demonstrated or disseminated.

4. Cost Sharing

Grantees or loan recipients must themselves fund at least 25% of the proposed program or project.

II. Program Grants/Loans

Specific Criteria

(1) No single organization may receive more than $75,000 in program grants or loans under the AID-financed portion of the Fund.

(2) Organizations must demonstrate capability and experience in the general field of the loan/grant application. That is, an applicant proposing to test cookstoves must demonstrate an existing test capability, an applicant proposing a tree planting extension must demonstrate proven extension experience etc. Organizations already reviewed by the AID Project Design Team and judged to be generally capable in specific areas are presented in Table H-1. This list should not, however, be interpreted as AID endorsement or recommendation for funding.

(3) No more than one-third of the AID-supported portion of the Fund will be allocated to GOK organizations.

Application Review and Approval Process

The MOE will solicit program grant or loans applications at least annually. The MOE will formally advertise for applications and will meet with organizations such as listed in Table H-1 to solicit interest well in advance of the applications date. Applications will be submitted to and reviewed and approved by MOE, which will hold the Authority to Incur Expenditures (AIE). Loan/grant approvals will be signed at the Deputy Permanent Secretary level or above.

Copies of program loan/grant applications relating directly to the activities of other GOK ministries will be forwarded by MOE to those ministries for review. A list of such review bodies is presented in Table H-2. Other ministries' comments are advisory only. Final grant approval authority resides solely with the MOE.

III. Project Grants/Loans

Specific Criteria

(1) No single project grant or loan may exceed $15,000, and no single organization may have more than two project grants or loans outstanding at the same time.

(2) As discussed below, no project with a local demonstration or extension component will be funded without prior written District Development Committee (DDC) approval.

(3) To assure distribution of projects throughout the country, each Province will be allotted a minimum level of project loan/grant funding which it can expect the MOE to commit to projects in its Province unless project applications are totally unsuitable. Such provincial quotas will take into account AID target regions and population groups as defined in the CDSS. The MOE and the projects long-term experts will assist each Province to develop suitable projects up to at least the Province's minimum quota level.

(4) Within each Province, preference will be given to projects in areas where AID target population groups are concentrated and to projects in which members of such groups are active participants.

Application Review and Approval Process

The MOE and District Development Committees will cooperatively solicit project grant applications at least annually. The MOE will advertise loan/grant availability to all DDC's, and MOE representatives will discuss the Fund personally with as many DDC's as possible. Then, a single national solicitation, including both national and local advertising/notification, will be held.

Grant or loan applications from Nairobi-based national organizations where the project does not have a local demonstration/extention component will be submitted to the MOE. All other grant or loan applications will be submitted to the appropriate DDC or, in the case if Nairobi, the Nairobi City Council for review and approval. DDC's and the Nairobi City Council will, by a date specified, submit their approved application to MOE. From this group plus non-local project grant or loan applications which it has received directly, MOE will select project for funding.

IV. Fund Administration

MOE will provide both technical and schedule monitoring and financial

management of all program and project grants or loans awarded under the Fund. MOE technical experts or advisors will meet with each organization receiving a program grant or loan and to the extent possible each receiving a project grant or loan in order to provide technical assistance at or near the start of the program or project. MOE also will provide all grantees with standard quarterly and annual cost, schedule, and technical reporting forms. Reports for all grants will be reviewed as part of the annual Renewable Energy Development Project reviews and as part of the AID Mid-Term Project Evaluation.

MOE will establish suitable accounting procedures for disbursing funds and assuring that funds are properly spent.

MOE will conduct a simple financial, technical, and management audit at least once during each program or project, on or before the eighteenth month from grant award or completion of the program or project, whichever is earlier. For local demonstration/extention projects, participation of District or Division Rural Development Fund (RDF) administrator or other designated DDC representative will be solicited and encouraged.

MOE will provide for closing out all grants at the end of the program or project, including receipt of the final report, final invoicing and reconciliation, and MOE final program/project evaluation. Ten percent of the RDF amount for any grant will be held back and disbursed only upon receipt of a suitable final report and of all necessary financial records.

Within the framework provided above, administration of the Fund should be kept as simple as possible. The application review process should provide for speedy approval at each level. Financial and administrative reporting and other requirements should be kept simple and appropriate to the small size of each loan/grant, due to the desire to involve local groups who may be better at local innovation and extension than they are at filling out forms, and the intent of using the loans or grants to accomplish tangible results rather than to create paperwork. Two useful models in this respect are the Rural Development Fund and CIDA's "Mission-Administered Funds" Program.

TABLE H-1

ILLUSTRATIVE PROGRAM LOAN/GRANT CANDIDATES
ENERGY DEVELOPMENT FUND

AFFORESTATION	MOA Soil Conservation Program MENR Rural Afforestation Extension Scheme National Christian Council of Kenya (NCCK) National Council of Kenya Women (NCKW) Peace Corps
OWNER-BUILT STOVES	MOA Home Economics Department MCSS Women's Bureau Peace Corps Egerton College Bukura, Embu Agricultural Institutes Farmers' Training Centers Karen VTU
COMMERCIAL STOVES	NCCK Village Polytechnics Kenya Industrial Estates Partnership for Productivity MENR Forest Department
CHARCOAL PRODUCTION	Village Polytechnics Kenya Industrial Estates
WATER SUPPLY SYSTEMS	Ministry of Water Development Peace Corps Kenya Industrial Estates CARE MOA Small-Scale Irrigation Program

TABLE H-2

ILLUSTRATIVE GOK REVIEWING MINISTRIES
ENERGY DEVELOPMENT FUND

AFFORESTATION/ AGROFORESTRY	Environment and Natural Resources Agriculture Livestock Development
OWNER-BUILT STOVES	Agriculture Culture and Social Services
COMMERCIAL STOVES	Industry
CHARCOAL PRODUCTION	Environment and Natural Resources Agriculture Industry
WATER SUPPLY SYSTEMS	Water Development Agriculture Land and Settlements

Table A-

KEY PARAMETERS OF ETHANOL PRODUCTION FROM DIFFERENT BIOMASS MATERIALS

	Unit	Molasses	Sugarcane	Cassava a/	Corn a/
A. YIELDS					
Ethanol Yield/ton of Biomass	liters/ton	270	70	180	370
Biomass Yield/ha of Land b/	tons/ha	n.a.	50	12	6
Ethanol Yield/ha of Land	liters/ha	n.a.	3,500	2,160	2,220
B. PROCESSING PLANTS					
Economic Plant Size Range	liters/day	60-240,000	120-240,000	60-120,000	120-240,000
Number of Operating Days	days/year	180	180	275	275
Annual Production in 120,000 liters/day Plant	- million liters/year	21.6	21.6	33.0	33.0
	- million US gallons/year	5.7	5.7	6.9	6.9
	- tons/year	17,100	17,100	26,100	26,100
Installed Cost of 120,000 liters/day Plant in:					
- Low Cost Countries c/	US$millions	6.8	7.6	9.1	9.1
- Medium Cost Countries c/	US$millions	7.6	9.5	11.4	11.4
- High Cost Countries c/	US$millions	11.4	14.3	17.2	17.2
C. ECONOMICS AS GASOLINE ADDITIVE					
Ex-Plant Biomass Raw Material Cost for 10% EBR d/					
- At US$31/bbl FOB Crude e/	US$/ton	62	14	13	neg.
- At US$35/bbl FOB Crude e/	US$/ton	70	16	17	1.2 f/
- At US$43/bbl FOB Crude e/	US$/ton	85	20	23	1.8 f/
Ex-Plant Biomass Raw Material Cost for 20% EBR d/					
- At US$31/bbl FOB Crude e/	US$/ton	65	14	16	neg.
- At US$35/bbl FOB Crude e/	US$/ton	73	17	19	1.4 f/
- At US$43/bbl FOB Crude e/	US$/ton	90	22	25	2.1 f/

a/ Based on current designs and fuel oil as fuel source.
b/ Based on current average yields in Brazil, except for corn which is based on US average.
c/ Low cost country data for sugarcane plants based on Brazil costs, others on data supplied by various sources and extrapolations by Bank staff. All costs in late-1979 Dollars.
d/ For medium cost countries.
e/ Assuming ethanol value equal to that of gasoline in volume terms. Gasoline price assumed as 1.3 times that of ex-refinery light Arabian Crude price, by volume; this relationship assumed to go down with increased crude prices. Crude price assumed to increase at 3% p.a. in real terms, gasoline price at 2.5% p.a., and raw material cost at 1.0% p.a.
f/ For corn US$/bushel. One bushel weighs 56 lbs. One ton equivalent to 39.4 bushels.

World Bank

Industrial Projects Department

May 1980

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ANNEX O. PERSONS INTERVIEWED

Mr. Mbote
Mr. Opundo
Mr. Wairegi
Mr. Kariuki
Mr. Nyoika
Mr. Mathenga
Mr. Bailey
Mr. Gathinji
Mr. Sha
Ministry of Energy
Nairobi

Mr. David Kamweti
Mr. Mbindi
Mr. Ciera
Foresters
Ministry of Environment and
Natural Resources
Nairobi

Dr. G.R. Rogalsky
Deputy Director
Wildlife Planning Unit
MENR
Nairobi

Dr. Walter Lusigi
Deputy Director
National Environmental Secretariat
Naiorbi

Mr. Moses Mukolwe
Head Land Development Division
Nairobi

Miss Grace Wagema
Head Home Economics and Youth Branch
Ministry of Agriculture
Nairobi

Mr. Waithaka
Head Crop Production Division
Ministry of Agriculture
Nairobi

E.G.P.DeNooy
Land Development Division -
Small Scale Irrigation Unit
Ministry of Agriculture
Nairobi

Dr. Carl Wenner
Soil and Water Conservation
Services Board
Ministry of Agriculture
Nairobi

Mr. George Hunt
Planning Division
Ministry of Agriculture
Nairobi

Dr. John Cohen
Deputy Assistant/Program Head
Harvard Institute for International
Development
Ministry of Agriculture
Nairobi

Mr. S. Makondiege
Deputy Director
Ministry of Water Development
Nairobi

Mr. Munoru
Self-Help Division
Ministry of Water Development
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Mr. Dixon Migwi
Geology Section
Ministry of Water Development
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Mr. Masa Khalia
Ministry of Economic Planning and
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Nairobi

ANNEX O. PERSONS INTERVIEWED (cont.)

Mr. Aburu-Kene
Central Bureau of Statistics
Ministry of Economic Planning and Development
Nairobi

Mr. Aleki-Dondo
National Council on Science and Technology
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Mr. Klaus Bethke
AID Rural Planning Project
Ministry of Economic Planning and Development

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William I. Jones
Economist
The World Bank
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Dr. Mikael Grut
Forest Economist
FAO/World Bank Cooperative Program
Rome, Italy

Dr. Peter Newhauser
EEC Program Officer
Machakos Integrated Development Program
Machakos

Ms. Coralie Turbitt
Director
Peace Corps

Ms. Sara Lucalo
Peace Corps

Dr. Hugh Lamprey
UNESCO
Integrated Arid Land Development Program
Nairobi

Dr. Gordon Goodman
Director
Beijer Institute
Stockholm

Dr. Phil O'Keefe
Beijer Institute/
Clark University
Nairobi (National Environmental Secretariate)

Cheryl Rounturner
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Mr. Donald Thomas
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Dr. Digby Swift
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Mr. Harold Miller
Director Rural Development Program
National Christian Council of Kenya
Nairobi

Dr. Paul Paetkau
Ecologist
National Christian Council of Kenya
Nairobi

Mrs. Kadzo Kogo
National Christian Council of Kenya
Nairobi

Mrs. Margaret Mugo
General Secretary
YWCA
Nairobi

Mrs. Jane Kiano, National Chairman
Mrs. Onsando, Executive Officer
Maendaleo Ya Wanawake
Nairobi

Mrs. Sandra Rafas
Institute For Cultural Affairs
Kawangware

Roger King
NCCK Consultant

Mr. Dilg
German Development Assistance
Nairobi

Mrs. Walter
Head of Women's Programs
Salvation Army
Nairobi

Randall Baker
(Advisor to NES)

Mr. E.G. Mugara
District Water Engineer
District Water Office
Nyeri

Mr. J.Kamau-Principal
Provincial Water Bailiff
Provincial Water Office
Embu Institute of Agriculture
Embu

Mr. Peter Young
Training Director
Village Technology Unit
Embu

Mr. Steven Wiggins
Assistant Planner
Provincial Planning Office

Brothers
Michale, Peter, Christopher
Mvega Catholic Mission
Nyeri

Andrew Clark
Technical Missionary-NCCK
Nanyuki

Mr. Ndiritu
Lecturer in Botony
Kenyatta University College
Embu

Mr. Mwangi
Director
Karurumo Village Polytechnic
Embu District

Rev. John Keys
Methodist Missionary
Meru

Mrs. Beatrice Kiruja
District Home Economics Officer
Meru

Mrs. Sally Innes
Div. Home Economics Officer (PCV)
Meru

Mr. Nels Christiansen
Water Engineer
District Water Officer (PCV)
Meru

Mr. Kaburu
Director Meru Museum
Meru Group Fuel and Fertilizer
Coop--Kitmirune

Mr. Richard Innes
District Agricultural Officer (PCV
Meru

John Davies
Ol Pegeta Ranch and neighboring
Mutara Ranch
Nanyuki

Mr. Njiraini
Forest Officer
South Marmonet Forest Station
Nyahururu

Mr. J. Kabura
Crafts Training Center
Nakuru

Dr. Koech
Rift Valley Institute of
Science and Technology
Nakuru

Mr. Onyeit
District Community Development
Officer
Nakuru

Mrs. S.A. Ombwara (Home Economist)
Dr. P.T. Obwaka (Principal)
Mr. E.P. Misiko (Technician)
Egerton College
Njoro

Mr. C.C. Wekullo
Provincial Planning Office
Kisumu

Mr. P.N. Muchiri
Provincial Water Engineer
Kisumu

Mr. J.T. Hansen
Provincial Planninc Office
(Rural Development Officer)
Kisumu

Mr. Nashan Okwaro
Plough and Allied Products LTD.
Kisumu

Ms. Lucy Waithera
Divisional Home Economics Officer
Vihiga

Mr. Lubarga
Parnership for Productivity
Kakemega

Mr. Hutchinson's assistant manager
Hutchinson Co., Tunnel Farms
Ft. Ternan

Mr. Davinder Lamba
Ms. Diana Lee-Smith
Ms. Lousie Buck
Mazingira Institute

Philoman Tones
ICRAF

AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT IDENTIFICATION DOCUMENT FACESHEET

To Be Completed By Originating Office

1. TRANSACTION CODE: [A] A = Add, C = Change, D = Delete

PID

2. DOCUMENT CODE: 1

3. COUNTRY/ENTITY: Kenya

4. DOCUMENT REVISION NUMBER: [ ]

5. PROJECT NUMBER (7 digits): 615-0205

6. BUREAU/OFFICE: A. Symbol: AFR; B. Code: 06

7. PROJECT TITLE (maximum 40 characters): Renewable Energy Development

8. PROPOSED NEXT DOCUMENT: A. [3] 2 = PRP, 3 = PP; B. DATE MM YY: 09 80

9. ESTIMATED FY OF AUTHORIZATION/OBLIGATION: a. INITIAL FY 80; b. FINAL FY 80

10. ESTIMATED COSTS ($000 or equivalent, $1 = 7.45)

FUNDING SOURCE		Life of Project
a. AID Appropriated		4,600
b. OTHER U.S.	1.	
	2.	
c. Host Country		1,200
d. Other Donor(s)		
TOTAL		$5,800

11. PROPOSED BUDGET AID APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. Grant	PRIMARY TECH. CODE D. Loan	E. FIRST FY F. Grant	E. FIRST FY G. Loan	LIFE OF PROJECT H. Grant	LIFE OF PROJECT I. Loan
(1) ARDN	740B	878		4,600		4,600	
(2)							
(3)							
(4)							
			TOTAL	4,600	-0-	4,600	-0-

12. SECONDARY TECHNICAL CODES (maximum six codes of three positions each): 374, 876

13. SPECIAL CONCERNS CODES (maximum six codes of four positions each): BRW, TECH, TNG, ENV

14. SECONDARY PURPOSE CODE:

15. PROJECT GOAL (maximum 240 characters)

Increase Kenya's agricultural and industrial production potential.

16. PROJECT PURPOSE (maximum 480 characters)

To assist the Government of Kenya (GOK) in developing appropriate energy policies, with an emphasis on renewable and non-conventional energy resources and technologies, especially as will benefit rural areas.

17. PLANNING RESOURCE REQUIREMENTS (staff/funds)

As detailed in PID text and Appendix D thereto, 20 persons are required, for a total of $300,000. Of this $90,000 would be funded under Project 615-0172 and $210,000 under PDS.

18. ORIGINATING OFFICE CLEARANCE

Signature: [signature]

Title: Ag. Director, USAID/Kenya

Date Signed: MM DD YY 03 21 80

19. Date Document Received in AID/W, or for AID/W Documents, Date of Distribution: MM DD YY

AID 1330-2 (3-76)

I. SUMMARY

The Renewable Energy Development Project (615-0205) provides $4.6 million over a three year period (FY 1981-1983). The project purpose is to assist the Government of Kenya (GOK) in developing appropriate energy policies, with an emphasis on renewable and non-conventional energy resources and technologies, especially as will benefit rural areas. A draft Logical Framework is at Appendix A.

Oil is the major source of conventional energy in the modern sector, and with no proven oil deposits, the importation of oil is having a crucial impact on the country's balance of payments. Hydro and geothermal resources for generating electricity are being developed, but with the rising demand for electricity, the known resources will be sufficient to meet the demand for only another 10-15 years, if all resources are fully exploited.

Nearly 90 percent of the population depends for cooking and other energy requirements upon fuelwood and charcoal. This situation is causing depletion of Kenya's forests resulting in degradation of the environment, e.g., soil run-off and river siltation.

The GOK recognizes the urgent need to develop renewable and non-conventional energy resources and to arrest the depletion of wood stock. The newly formed Ministry of Energy has been mandated to deal with energy policy and with development and application of renewable energy technologies appropriate to the socio-economic, cultural and climatic conditions of Kenya. Assistance is provided for preliminary planning and surveys of national energy use, with emphasis on appropriate rural uses of renewable energy including fuelwood. Initial staffing and follow-on training is included to strengthen policy formulation, planning, evaluation and services capabilities within the MOE, and for outreach activities. Selected feasibility and demonstration projects are supported in order to permit MOE and the Ministry of Environment and Natural Resources (responsible for the afforestation program) to deliver the "state of the art" for use by the people, especially the rural poor. Minor but cost-effective assistance will be provided to the Ministry of Works in the energy-efficient design of public buildings. Monitoring and evaluation of project effectiveness will be conducted in a format designed to encourage the dissemination of lessons learned.

Major project elements include (1) initial planning and surveys ($850,000); (2) institutional development ($1,700,000); (3) applied research, demonstration activities and feasibility studies ($1,750,000); and (4) monitoring and evaluation ($300,000). Principal inputs include short and long-term technical assistance $2,800,000); training ($1,050,000); and commodities ($750,000). All elements are of course subject to review and change during project design.

USAID would expect to approve this project at post, following AID/Washington PID approval and initiation and completion of project design. Authority to include in the project authorization approval

to permit purchase of non-U.S. source vehicles (Land-Rovers) at a total cost not to exceed $100,000 is also requested. In view of the importance of the project, it is proposed for FY 80 funding should funds prove available.

II. BACKGROUND

A. Kenya Energy Problems

1. Conventional Energy*

The sources and consumption of conventional energy in Kenya in 1978 were as follows (all figures in '000 Tonnes oil equivalent);

Coal and coke imports - 34.8
Oil Imports - 1659.9
Hydro Energy (local production) - 257.5
Hydro Energy (imported from Uganda) - 52.1
Total Energy Consumption - 2004.4
Local production as percentage of total - 12.8
Per capita consumption in terms of kilogram of oil equivalent - 135

(i) Oil:

Oil is the major source of conventional energy in Kenya - it accounted for more than 80 percent of total conventional energy consumed in 1978. The amount Kenya has spent on net imported oil has increased from K£1** million in 1973 to K£47 million in 1978, so that now about 23 percent of the nation's foreign exchange earnings is used for petroleum. Kenya imports about 13 million barrels of oil annually. While exploration for oil continues, no major resources have been found to date.

Following general patterns found in most nations, the transport sector is the largest consumer of oil, accounting for 64% of the total use. Industrial and commercial enterprises account for another 25%;and the rest for lighting and generating electricity in thermal plants.

There has been a consistent upward trend in consumption of petroleum products since 1974, the increase from 1974 to 1978 being 24 percent. Most of the increase in consumption in 1978 compare to 1977 occurred in sales of motor spirits, jet fuel, illuminating kerosene and light diesel oil, the most significant increase being in the sales of lighting kerosene which went up by 21 percent compared to 1977. The main reason for the increase in the sales of kerosene was because low

*Economic Survey 1979 - Chapter 10 "Energy" For details, see Appendix B
** One Kenyan pound = approximately $2.74.

income householders, major consumers of charcaol, substituted with kerosene because of rises in prices of charcoal during the year.

(ii) Hydro and Geothermal:

The primary indigenous resource for electricity at present is hydro, which accounted for 12.8 percent of the total energy consumed in 1978. Kenya's hydro-power resources are now being developed and the present hydro-electrical generating capacity of 295 MW* is expected to rise to 510 MW by 1983. Kenya's total potential power resources are estimated to be about 1000 MW.

Kenya's geothermal resources are also now being developed. The first generating plant at Olkaria, near Lake Naivasha, is expected to come into production in 1981, adding a capacity of 15 MW to the electrical system. Provided funding is obtained, successive plants will be built at Olkaria until its total capacity of 170 MW is reached. Studies indicate that Kenya's entire geothermal potential may be as much as 500 MW.

The demand for electricity is rising at the rate of 9 percent; therefore, the demand for electricity at present and for the next 10-15 years can be met from available hydro and geothermal resources, if these are fully exploited, as shown in the following table:

Table 1

	1983	1988	1993	2000
Hydro	600	600	600	600
Geothermal	30	170	500	500
Total supply potential	630	770	1,000	1,000
Projected demand	362	517	747	1,267
Surplus/deficit	268	253	353	-167

Hydro and geothermal power in Kenya is consumed primarily by the modern, urban sector. The main exception is the rural electrification program. The GOK plans to spend about K£4.2 million during the 1979-83 development plan period on rural electrification, basically to serve densely populated rural areas. Furthermore, electricity is used primarily for lighting and other commercial and developed purposes, rather than for cooking, which is the basic energy need for the rural population.

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*Other generating capacities and sources are: Steam (98 MW), diesel (32 MW) gas turbine (30 MW), import from Uganda (30 MW).

2. Renewable and Non-conventional Energy in Kenya:

(i) Fuelwood

Rural people, along with most of the urban poor which total 90 percent of Kenya's population, continue to rely on wood and charcoal to meet their traditional energy needs. If such woodfuels are estimated in terms of oil equivalent, they account for between 73% and 84% of Kenya's total energy consumption. Yearly consumption of woodfuel is more than twelve million tons, (or 1 ton per capita) and is projected to increase at a rate of at least 4% per year, in keeping with the growth of population. It is estimated that one-half of Kenya's remaining woody cover will be stripped in the next one to three decades, thereby causing serious degradation of the environment.

Afforestation programs have been implemented in Kenya for many years by the Forestry Department of the Ministry of Environment and Natural Resources and private voluntary organizations and private enterprises. The Government's gazetted* forest areas are managed by the Forestry Department, which sells forest products to industries (such as a plywood factory paper mill and training factories) and to public for fuelwood and charcoal. The total area under forest plantation amounted to 158,000 hectares in 1978 compared to 152,600 hectares in 1977. The reserved forest areas supply only 700,000 cubic meters (Statistical Abstract 1977) of fuelwood and charcoal which amounts to nearly 6 percent of the national consumption. Therefore, there has been uncontrolled cutting of trees in other areas such as trust lands and private land holdings. Because of insufficient technical personnel and resources for setting up tree nurseries and distributing samplings, the reforestation of non-gazetted areas has not kept pace with cutting of trees for fuelwood and charcoal.

Four main factors account for the rapid depletion of wood stock: (1) the increase in population**; (2) the inefficient methods of converting fuelwood into charcoal for use in urban and high density agricultural areas; (3) land demand for agricultural production; and (4) the unavailability at reasonable cost of alternate energy sources.

With over 80 percent of the country's land area classified as arid or only marginally productive, and with only 12.5 percent of the land area supporting over 75 percent of the population, Kenya's land frontier is rapidly closing. This situation has serious

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*i.e., formally and legally set aside.

**Kenya is experiencing one of the fastest population growth in the world, at about 4.0 percent per year, and an even faster rate in two of its already most populated areas, which are essentially rural, i.e. Western and Nyanza Provinces.

***Taken from proposal by Mazingira Institute, "A pilot project to develop, implement and evaluate an approach for establishing agroforestry plots in rural Kenya."

implications for the rural poor as well as for the nation's long-term development prospects. First, the need for agriculturally productive purposes, to support the population's food requirements, has resulted in massive and wasteful clearance practices. This expansion of cultivated hectarage combines with the rural population's enormous demand for fuelwood to cause significant deforestation in many areas of the country. Preliminary studies on fuelwood supply and demand conclude that the existing and planned production of fuelwood from forests is entirely inadequate to meet present and future demand on a sustained yield basis. The result is that commodities which the subsistence farmer has been accustomed to obtaining free of charge are now costing him/her, either in the form of decreased agricultural productivity through labor sacrificed to extensive fuel gathering or in actual cash for purchase of substitutes, usually charcoal. Second, the depletion of forests has the effect of rapidly bringing about soil erosion and nutrient depletion. These processes, in the absence of remedial measures, can have devastating consequences for the long-term productivity of rural lands and can bring about inter alia, river siltation and consequent reduction of hydro-electric potential.*

(ii) Other Renewable Energy

An ethanol plant, a joint-venture between the public and private sector, is under construction in Kisumu. The plant is expected to produce 20 million litres of ethanol per year by 1984. The first phase will come into production in 1981 and will supply approximately 15 percent of Nairobi's fuel requirements. When the plant is in full production in 1984, it will supply 10 percent of the country's fuel requirements. Ethanol will be sold to oil companies for distribution to consumers.

A few GOK-sponsored pilot projects on the use of biogas, solar and windpower as alternate sources of energy have been initiated, mainly in the rural areas. For example, methane digesters are being tested in Meru, solar water pumps in Wajir, and wind machines in Kisumu District. The UNICEF-sponsored village technology units are testing solar crop dryers, wind machines, bicycle-powered pumps, and biogas plants. These experiments have, however, been too few in number to yield reliable data for broad-scale planning purposes, especially with respect to adaptation to Kenya's cultural and other conditions.

There are some application of technologies in the private sector. For example, methane digesters are used on a number of larger farms in Kenya. Solar water heaters are produced by several companies in Nairobi and many of Kenya's hotels and lodges are equipped with them. Further development of a private industry to manufacture alternative

*AID Project No. 698-0427, Environmental Training and Management will provide some data on environmental degradation of land due to deforestation and soil erosion.

energy technologies may be possible. Research on alternative technologies is also underway in the Engineering Department of the University of Nairobi.

In brief, the development of alternative energy technologies has not progressed far enough for the Government to initiate wider applications. Considerable data gathering, feasibility studies and experimentation, as well as institution building, are in USAID/GOK judgement necessary before large-scale investment should properly be undertaken.

B. Policy Considerations

The Government of Kenya has in recent years taken major steps toward dealing with certain of the energy problems described above. Already in progress are programs for developing geothermal and hydroelectric sources of electrical energy, and for manufacturing ethanol for "gasohol". The GOK has also recognized the need to develop and promote the utilization of non-conventional and renewable energy sources, such as wind, solar and biomass, and to undertake afforestation programs. Above all, the GOK has made a major commitment towards coordinating all of these efforts within the context of a national energy policy and of strategies to achieve such policy. The Ministry of Energy has been established as part of the "Nyayo" (post-Kenyatta) Government; under strong leadership, and with technical and other forms of assistance, the GOK can be expected tointensify these efforts. Policy considerations which must be addressed in the process are summarized as follows:

1. Conventional Energy

Official Kenyan policy is predicated on the obvious necessity of importing oil for the growing economy. One thrust of this policy is to rationalize and conserve the use of imported petroleum; the other is to develop indigenous resources to reduce dependence on petroleum. The Development Plan for 1979-83 states that activities in the oil sector will mainly consist of investments in the refinery at Mombasa to improve product yields of crude oil; improvements in the efficiency of distribution by the oil companies; rationalization of the use and conservation of oil; oil exploration; and the development of power alcohol.

Conservation of oil, while important, would have only a limited impact: The Development Plan estimates that at best 7% to 10% of oil now being used could be saved. Possible conservation measures include, e.g., increase tax on petrol and increased duty on cars with large engines. Experts have suggested immediate conservation actions, including construction of bicycle paths in Nairobi, increased use of school buses, and petrol rationing or a prohibitive tax on use of petrol for non-essential

uses. In the longer term, an integrated approach to fuel and eletricity pricing and full market pricing of both, would help to rationalize energy consumption. Social policy questions need to be discussed in policy formulation such as the role of private automobiles vis-a-vis public transportation and the congruity of regulations governing the construction of new buildings and industries.

Electricity will continue to be developed for those who can afford it (Kenya is one of the developing countries with the highest prices for electricity). Both major hydro and geothermal resources are also likely to be exploited to the fullest extent allowed by economic and technical constraints. Small hydro plants might also contribute significantly.

As shown in Section I above, demand for energy is expected to continue escalating at a dramatic rate and foreign exchange costs of petroleum imputs are already straining the economy. Development of renewable and unconventional energy resources is therefore clearly a top GOK priority.

2. Non - Conventional Energy:

(i) Fuelwood:

To meet the demand for forest products by industries, and for fuelwood, there is a need to expand afforestation efforts in areas such as (a) Government owned forest reserves, (b) trust lands held by county councils and (c) private small land holders. Establishment of village lots and household lots for fuelwood should receive immediate attention. It is believed that the Forestry Department at present has sufficient technical personnel to manage the Government's forest reserve areas. However, additional personnel and resources are necessary for setting up tree nurseries and a distributing system. Also, the supply and demand for fuelwood varies depending upon the ecological conditions; therefore a fuelwood survey for each district* of Kenya is required. Also, improvement in the efficiencies of charcoal kilns and cooking stoves is necessary to reduce the demand for fuelwood.

(ii) Renewable Energy

Because the supply of hydro and geothermal power, primarily consumed by the modern, urban sector, is limited, and because increases in price of imported oil are draining badly needed foreign exchange, the GOK must accelerate the application of renewable energy technologies, especially in rural areas. To undertake such a program, MOE's capabilities in the field of formulating policies and evaluating various technologies must be strengthened.

*This survey would likely include, of Kenya's 41 districts, detailed study of perhaps all 25 heavily populated districts and a representative study of some, perhaps 5, of the remainder.

Various technologies, such as solar and wind power, and biomass, have been tested in many parts of the world and to some extent in Kenya; see Section II B 2(ii) above. However, for possible early application in Kenya, it is necessary that these technologies be tested more extensively and appropriate modifications made to suit Kenya's socio-economic, cultural and climatic conditions.

As a long-term program, the GOK wishes to establish a major institute in Kenya for applied research in the field of energy. Also under consideration has been a possible Rural Energy Bank (whether as a new institution or a new lending facility at an existing banking institution); this Bank would make concessional financing available to rural businessmen and rural smallholders to stimulate their use of renewable energy technology.

3. General Comment

GOK officials prefer, understandably, not to undertake major energy commitments or investments until and unless the above outlined policy concerns have been sorted out; Kenyan energy institutions strengthened; and successful results, applicable to socio-economic, cultural and climatic conditions of Kenya, are fairly certain. It is to assist the GOK toward these objectives that this PID is submitted.

III. PROJECT COMPONENT SUMMARY

The Renewable Energy Development Project is intended to assist the GOK in addressing effectively the range of problems and policy consideration outlined above; and, more specifically to facilitate systematic development by the GOK of renewable and non-conventional energy resource policies and technologies. The project toward these ends includes four interrelated components each discussed below:

(i) initial planning and surveys;
(ii) institutional development;
(iii) applied research and demonstration; and
(iv) monitoring and evaluation.

(i) Initial Planning and Surveys:

Long and short-term technical assistance, training, and commodities are provided to develop GOK capability in the survey and data areas, for preliminary planning, fuelwood survey and a national energy plan. For example, it will be necessary to undertake a survey of energy uses in rural areas for lighting, heating, cooking, water pumping and processing of agricultural products.

For an effective afforestation program throughout Kenya, a fuelwood and charcoal survey for represetative districts is required. In this regard, under the auspices of Beijer Institute, Stockholm, a fuelwood study group has been formed. This group met on January 8-9, 1980 and a USAID/K representative attended the meeting as an observer. The group has formed a committee to draft a scope of work for a detailed fuelwood demand/supply study. A draft scope of work is expected to be ready for review by the group on March 24, 1980. The draft will then be submitted to GOK for review and comments. Some funding ($250,000) may be available from the Swedish Agency for Research (Co-operation with Developing Countries) and Rockefeller Foundation. To avoid duplication of efforts and minimize administrative problems associated with that one group, it is intended that the fuelwood study proposed by the Beijer Institute be incorporated with the project proposed in this PID.

Also, provision has been made in this PID for commodities, such as publications, necessary to set up an energy Data Bank and Library in MOE so that all information on matters related to energy will be available from one source.

(ii) Institutional Development:

Technical assistance will be provided for assistance in organizational, management and policy making aspects of the planning and evaluation divisions and one or more technical divisions of MOE and the Department of Forestry. Major T.A. will be on a residency basis, furnished by a planner, an economist, and an engineer (all renewable energy specialists), and by a forestry/woodlot expert.* Short-term technical assistance (in such areas as sociology/anthropology) will be provided as needed. Training of Kenyan counterparts and limited commodity assistance will also be provided.

(iii) Applied Research and Demonstration:

Support for several specific technologies is provided on a pilot demonstration basis. In this regard, Government is anxious to develop alternate energy resources for delivery to the rural poor. Several technologies have been developed sufficiently to permit their introduction on a modest scale. These might include: village and household level reforestation and agroforestry; improved stoves and kilns; biogas; small-scale alcohol or medium-scale methane generation; solar devices for drying and heating; heating pumping systems; food processing systems; and small-scale electricity generation for rural clinics, schools, communications and in support of other rural services. Further applied research might be necessary at existing institutions such as University of Nairobi, the Kenya Agricultural Research Institute,

*Subject to a design team's finding, it is suggested that only one resident T.A. planner at the Dept. of Forestry is necessary since that agency has for some time been established and functioning and needs assistance primarily in one area, i.e., stimulating of village level woodlot developme

Egerton College, and/or the Karen Village Technology Unit. All technologies to be demonstrated and tested will require in-depth socio-economic analysis so that technologies eventually developed for wider applications are acceptable to rural people. In addition, to meet an ad hoc GOK requirement, short-term consultants to the Ministry of Works will be provided to assist in design of public buildings on energy-efficient bases.

(iv) Monitoring and Evaluation

The project provides for periodic monitoring and evaluation. This project component will be fully developed during the design process but, at this point, one external evaluation at the 18 month point and a terminal evaluation at the 36 month point seem likely. Emphasis will be on evaluations providing meaningful feedback and looking to dissemination of lessons learned.

IV. PROJECT BENEFICIARIES

The development and thereafter application of renewable and non-conventional energy policies and technologies will be intended to reduce the demand for imported oil for activities, inter alia, such as cooking, lighting, heating, water pumping and processing of agricultural products. The resultant savings in foreign exchange due to reduced importation of oil will benefit Kenya's people in general. Thus, at one leyel, macro-economic benefits in terms of significant foreign exchange savings* are seen as flowing from the project.

Under the afforestation aspect of the project, the major category of direct beneficiaries will be those rural residents and urban dwellers (all low income) who now depend heavily or exclusively on wood and charcoal for cooking, heating and processing and who are threatened with the loss of this primary source of cooking and heating fuel. Such beneficiaries include substantial numbers of women and children who spend several hours a day in gathering fuelwood. Smallholders will also be primary beneficiaries in that they will be able, ultimately, to devote more land and labor to crop cultivation as opposed to fuelwood growing and gathering.

Another category of potential beneficiaries is the class of small businessmen, primarily rural, who should benefit from availability at reasonable cost of energy-efficient equipment, i.e., powered by solar, wind, biomass etc. This same class should benefit specifically from credit available through the proposed Energy Bank, assuming that institutions upon study proves feasible.

Additional economy-wide benefits will come from improved environmental conditions (reduced silt run-off and air pollution, for example) associated with increased use of renewable energy resources.

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*These savings are difficult to quantify but, to illustrate, at current prices a 10% reduction in imported oil would mean about a $15 million FX savings.

V. ALTERNATIVE PROGRAM APPROACHES

Assistance could, possibly, be extended for capital and commodity assistance toward the development of particular energy technologies on a large-scale investment basis. Swiss and Austrian assistance has taken this form in projects to develop methanol plants. The World Bank has been actively assisting development of geothermal power sources. UNIDO has expressed an interest in assisting Government in laucnhing a number of pilot projects to produce energy from biomass (such as coffee, waste, sugar cane waste, maize husks, pineapple, etc.). USAID/Kenya believes that these capital investment projects are laready straining the GOK's capacity to implement and evaluate specific projects and that training of personnel and other forms of institutional development are necessary before major new undertakings go forward. A second reason for USAID's rejecting an approach which places heavy emphasis on a particular technology involves our and the GOK's lack of knowledge of the best technology to emphasize; a period of planning, training and some experimentation seems, again, much needed before significant investment is made in particular technologies.

The preferred approach for AID involvement, therefore, as we see it, is one which will emphasize (a) institutional building and policy formulation; (b) training of Kenyans in futherance of such institutional development; (c) limited number of pilot projects, feasibility studies and the like; and (d) dissemination and replicability of lessons learned. Thus the project proposed herein strikes a balance between the need to support start-up activities through work at the headquarters level and the need to put usable technologies into field use at some reasonably early date.

VI PROJECT ISSUES

A) Possible Follow-On Activities

This project does not include major investment activity in energy development per se. By 1982 the shape of a Government fuelwood program may be sufficiently developed for the U.S. and other donors to consider substantial investment. In addition, assistance may be sought for the construction and staffing of the proposed Energy Research and Development Institute (to be studied under this project) and/or capital for the Rural Energy Bank. The current USAID view is that (a) resources for Kenya from the AID budget will likely prove tight in later years and (b) other donors could perhaps be better able to meet such requirements. However, later AID investment in such projects is not ruled out; see Section VIII below.

B) Trained Personnel

Lack of trained personnel is a serious constraint to the Ministry of Energy and the Government as a whole, and may impede successful accomplishment of project objectives. However, training of Kenyans is an important componenet of this project and every attempt will be made to ensure that such training is received and disseminated.

C) GOK Policies

For project goals to be achieved (see Appendix A), the GOK will have to formulate policies to encourage conservation of conventional energy. Possible areas of interventions by GOK are tax credits, use of railroads instead of trucks for long hauls, improving public transport system, etc. The technical assistance team proposed for MOE will be working with MOE in these and related areas.

D) Coordination of Applied Research and Development Projects

The GOK is interested in pursuing the demonstration, testing, and implementation of several renewable energy technologies. Some of these, such as minihydro and biogas, require initial feasibility studies to determine the most appropriate scale and method of implementation of the ventures. Others, such as improved cooking stoves, may be ready for early implementation once cultural acceptability and other factors have been examined more closely. It is important that these efforts be coordinated and managed in such a way that delivery to the people is expedited. It is also important that knowledge and experience already gained elsewhere be applied to each new activity to prevent needless and expensive duplication of effort. Therefore, definition of a coordinating mechanism within MOE for activities to be undertaken under this proposed AID-funded project, will be an essential aspect of project design. (See also Issue F. below). In addition, full exchange of information with other donors as to their plans will be necessary during the design stage, again to avoid duplication and to ensure efficient use of scarce resources.

E) Technology Applications

Some technologies associated with this project have to a large extent been tried on a demonstration basis at the Karen Village Technology Center, located near Nairobi. Principal problems as to at least some of these technologies appear to be not ones of feasibility, but of cultural acceptability. Through use of sociological/anthro anthropological expertise, attempts will be made to overcome such cultural resistances.

F) Institutional Capabilities and Involvement

The various ministries concerned with the different uses of energy technologies obviously have a voice, in addition to MOE's,in formulating and implementing policy. For example, the Department of Forestry (Ministry of Environment and Natural Resources) has already been responsible for afforestation programs throughout the country; the Ministry of Agriculture has sponsored research into improved charcoal kilns; and the Ministries of Housing and Social Services and Works could become responsible for promulgating and enforcing energy-efficient building designs in all new Government housing. The difficulties associated with familiarizing personnel of various Ministries with aspects of the energy issues, and with courses of action to be proposed by MOE, will have to be identified and addressed. Perhaps also, MOE's role and mandate in energy coordination will have to be clarified.

There are also numerous small organizations which are or could become involved in carrying out energy projects. Non-profit organizations like the Association for Education and Development are experimenting with alternative technologies. The Wildlife Clubof Kenya, which works with the schools throughout the nation, is promoting a tree-planting program. Two other conservation groups, the East African Wildlife Society and Wildlife Fund, are involved in forest conservation. One of the several women's organizations in Kenya has also conducted a tree-planting program. Finally, there are several missionary groups in Kenya's rural areas who could play a role in distribution and education. Coordination and stimulation by MOE of the activities of these various organizations, in the interest of cost-effective utilization of renewable energy resources, is another issue which merits study at the design stage.

VII. PROJECT BUDGET COMPONENT (LIFE OF PROJECT)

The following budget is merely illustrative and subject to change during project design. The figures include 20 percent contingency and 30 percent inflation and assume FY 81 project authorization.

	T.A. (S-,L-T)	TRAINING	COMMOD.	LOP TOTAL
		($000)		
A) Initial Planning Surveys	750	50	50	850
Consisting of: (i) preliminary planning; (ii) fuelwood survey; and (iii) national energy survey.				
B) Institutional Development	1,000	600	100	1,700
Consisting of: (i) MOE organizational and management planning and policy making; (ii) MOE planning and evaluation divisions (incl. L-T energy engineer); and (iv) Dept. of Forestry extension divisions (Forester) (incl. L-T Forester).				
C) Applied Research and Demonstration	850	400	600	1,750
Consisting of the following: (i) village/household level reforestation and agroforestry; (ii) wood and charcoal stoves, charcoal/kilns; (iii) other biomass (small-scale alcohol, medium-scale methane; (iv) solar energy devices (water heaters, crop drier, etc.); (v) water pumping system (wind mills, solar cell and hand pump, etc.); (vi) food processing systems (e.g., grain grinders); (vii) feasibility studies of (a) Energy Research and Development Institute and (b) Rural Energy Bank; and (viii) short-term solar and windmill experts to assist Ministry of Works.				
D) Monitoring and Evaluation	300			300
Total Project:	2,800	1,050	750	4,600

(Note: At this time it is not realistic to offer illustriative budget in greater detail than by main component.)

VIII. RELATIONSHIP TO GOK DEVELOPMENT PLAN AND CDSS

The GOK (1977-1983) Development Plan strategy contains an energy sector analysis (Appendix C to this PID). This analysis recognizes and elaborates on many of the problems outlined above. The GOK also recognizes that the development of energy institutions in Kenya is just beginning. In this regard, the newly created Ministry of Energy is responsible, under a recently issued Presidential Circular, for the planning and development of energy policy. At this point, MOE is thinly staffed, and most personnel that it does have are not trained in energy management. MOE, with GOK endorsement, is actively seeking donor assistance for several non-conventional energy projects (e.g., the IBRD-funded geothermal project near Naivasha). With assistance to be provided under this project, MOE further intends to stress its own institutional development; to consider establishment of an energy-oriented applied research and development institute to further applied efforts; and to provide training in applying non-conventional energy technologies.

The Mission CDSS for FY 82 identified energy requirements as one of the key development problems facing Kenya at this time. Assistance of the kind envisioned by this project is proposed and justified in the CDSS, as is possible additional assistance in years 1984 and 1985 for wider applications of proven technologies and afforestation programs.

The project projected in this PID is thus seem as fully consistent with both the GOK's Development Plan, other GOK planning documents, and the CDSS.

IX. PROJECT PREPARATION STRATEGY

Project conception as presented in this PID involved frequent consultations with the National Council of Science and Technology, the newly formed Ministry of Energy and the Department of Forestry. Exploratory meeting between USAID and these offices enable Government to define its needs in terms of USAID ability to offer assistance. Representatives from AFR/DR/SDP participated in discussions leading to preparation of this PID and, later, reviewing the draft PID with the GOK.

A project design team for recruitment and commencement of work as early as possible in FY 80 is envisioned. The team would consist of an energy planner (team leader); a solar energy engineer, a wind-power engineer, an energy economist, two forestry experts* (a silviculture expert and a nursery

*The feasibility study for afforestation and tree nurseries funded under the Arid and Semi-Arid Lands Development (ASAL) project 615-0172 is integrated with the study for the energy project. $90,000 has been budgeted in the ASAL project for two forestry experts. See Appendix D hereto for justification and details.

expert) a public administration/training advisor and an anthropologist. The project design process will, if possible, include: (i) an energy planning workshop to be carried out in min-June by the Institute for Energy Research (IER). Stony Brook, USAID, AID/W and Kenya officials will draw upon IER's computerized "AL-EDIS" planning information system as an initial step for the energy sector analysis, and (ii) review in late June of the scope of work prepared by the fuelwood group under the auspices of Beijer Institute, Stockholm, and recommendation for changes, if any, required to integrate Beijer's fuelwood study with this project. The design team will thereafter conduct in-depth consultation with appropriate Government Ministries and institutions, and USAID/Kenya. Proposed Scope of Work for the design team is attached hereto (Appendix D).

Based on the outcome of the PID review processes in AID/W, and the speed with which a design team can be recruited and fielded, FY 80 funding of the project would be possible, assuming availability of funds. Estimates as to funding requirements used throughout this PID have, however, been prepared on the premise of FY 81 authorization; thus FY 80 authorization would result in some cost reduction as well as earlier realization of benefits.

Project Implementation would be within the USAID's Multisector and Engineering Office, with a direct-hire engineer (USAID Energy Officer) serving as Project Manager. All requisite skills are available within USAID and REDSO to support this project as necessary.

As estimated project costs are less than $5 million, and assuming this estimate is verified by the design process, USAID would expect to approve this project at post, based on Delegation of Authority No. 141.

INITIAL ENVIRONMENTAL EXAMINATION

No negative environmental impact of the total project is expected since the project does not include any major interventions which would affect physical, socio-economic, or cultural environment in Kenya. Therefore, a negative determination is recommended. (See Appendix E for IEE).

XI. WAIVERS

A need for approximately five project vehicles is envisioned, for project-related use of both U.S. technical advisors and GOK personnel. Total cost should not exceed $100,000. These vehicles must be right-hand drive, and should most likely be four-wheel Land-Rovers, assembled in Kenya from parts made in the U.K., for the reasons that (a) spare parts for U.S. vehicles are not easily available in Kenya; and (b) Land-Rovers are by far the type of four-wheel drive vehicles most easily serviced and maintained in Kenya.

A waiver approval request is at Appendix F. This would permit the Mission, in approving the project, to include, as to project vehicles, both (a) waiver of the U.S. source requirement and (b) approval of sole-source procurement of Land-Rovers. Total authority to procure vehicles would not exceed $100,000 without further referral to AID/W.

Appendicies:

A - Logical Framework

B - Economic Survey - 1979. Chapter 10, Energy

C - Development Plan. 1979-1983, Energy Sector

D - Scope of Work for Project Design Team

E - Initial Environmental Examination

F - Source Waiver Approval

LOGICAL FRAMEWORK (PID STAGE)*

Appendix A

Renewable Energy Development: Project 615-0205 | Life of Project: FY 81 - FY 83 | LOP: $4.6 million | Date: February 1980

NARRATIVE SUMMARY	INDICATORS	ASSUMPTIONS
A. GOAL LEVEL		
Increase Kenya's agricultural and industrial production potential.	1. Availability of adequate energy resources for agriculture and industry. 2. Reduced dependence on imported petroleum energy (achievement of energy balance). 3. Controlled further environmental degradation.	1. GOK will implement relevant energy policies. 2. Renewable energy policies and appropriate technologies will permit viable and acceptable substitutes for petroleum-based energy. 3. GOK will establish institutions and undertake programs identified and tested in feasbility studies and demonstration activities. 4. Afforestation programs and policies will be implemented by GOK and will lead to reduced soil erosion and degradation of water sheds.
B. PURPOSE LEVEL		
Development of renewable and non-conventional energy resources policies and technologies.	1. Basic energy and related technology policies established. 2. MOE capable of formulating energy policies and managing appropriate technology developments. 3. MOE identifies and enchances replication of specific energy technologies.	1. National energy plan results in basic policies formulated. 2. MOE staff training and MOE operational enhancement facilitate energy policy formulation and review and identification of appropriate energy technologies. 3. GOK implements recommendations on establishment of Applied Energy Research Institute. 4. GOK implements recommendations on establishment of Energy Bank
C. OUTPUT LEVEL		
1. National energy Plan. 2. Renewable Energy Division of MOE expanded, staff trained, and functions identified. 3. Fuelwood Survey. 4. Feasibility Studies 5. Applied Research and Demonstration Activities. 6. Evaluations.	1. Plan completed. 2. a. MOE staff trained. b. Division's duties and reponsibilities identified. 3. Survey completed. 4. Institutional development feasibility studies completed on Applied Energy Research Institute and on Energy Bank. 5. Applied research and demonstration activities completed on village woodlots (fuelwood), solar and wind power, and biogas and biomass (agricultural residue) 6. Evaluations completed.	1. Inputs delivered in timely fashion. 2. GOK resources allocated in timely fashion. 3. MOE is central focus for GOK's energy policy and technology development activities. 4. TA identified appropriate to MOE needs. 5. Training appropriate to MOE, GOK, and Kenyan needs.
D. INPUT LEVEL		
1. Technical Assistance (TA). 2. Training for GOK Staff. 3. Commodities.	1. $2.8 million for 12 person years of long-term TA, and 40 person months of short-term TA. 2. $1.05 million for 40 person years of short-term and long-term training. 3. $0.75 million for relevant project commodities.	Project authorized.

*Does not include "means of verification" at this preliminary stage nor are indicators fully quantified or targeted.

Overall consumption of energy in the country rose by a further 6 per cent in 1978 as compared to an increase of 4 per cent in 1977. The increase in 1978 can be attributed to the expansion of existing industries and construction of new ones as well as to general economic growth. The increase has occurred mainly in consumption of electric energy while consumption of oil products, the other main source of energy, went up marginally. On a per capita basis consumption of energy was 2 to 3 per cent higher in 1978 as compared to 1977. The comparison below shows, in index number form, the growth in monetary GDP and consumption of energy with consumption of oil separately identified.

	Growth in Monetary GDP	*Increase in Consumption of Conventional energy**	1972=100 *Increase in Consumption of Oil*
1973	107	107	105
1974	109	108	105
1975	112	111	108
1976	118	122	121
1977	128	127	125
1978	136	135	129

*Oil, electricity and coal and coke.

10.2. The figures above indicate that the increase in monetary GDP and the growth in consumption of energy appear to have a one to one relationship. This relationship can be attributed to the close ties which the modern economy has with the use of conventional sources of energy. GDP has, however, increased at a faster rate than the growth in consumption of oil products. This is due to the lagged effected of price rises, that have occurred since 1973, on the consumption of oil. Without a structural change of any significance the critical relationship between oil consumption and growth in GDP does never-the-less continue to have a crucial impact on the country's balance of payments.

Oil

10.3. Oil is the major source of conventional energy in the country. Despite the lower growth rate in its consumption in relation to monetary GDP and to total consumption of energy, it accounted for more than 80 per cent of total energy consumed in 1978. Its share of total consumption in 1977 was 85 per cent. The decline can be attributed to the installation of additional capacity for generation of hydro-electric power which was added to the system in 1978. As a result the share of hydro and thermal electricity in the total consumption of energy has increased from .2 per cent in 1977 to 15 per cent in 1978. Coal and coke account for about 2 per cent of the

remainder. The non-conventional sources of energy, i.e. fuelwood and charcoal, which serve 90 per cent of the total population are excluded from this comparison. If they were included the relative share of oil in total consumption of energy would be significantly reduced.

10.4. The modern sector of the economy in Kenya, however, relies very heavily on oil as a major source of energy, and it has been adversely affected by price increases and an insecure supply position for the last few years. The troubles in Iran in 1978 and 1979 led to shortages of aviation spirit early this year which affected the tourist industry as many light aircraft used by tourists for travel within Kenya were effectively grounded. The recent fare increases on international air routes have been forced on the operating airlines by the oil price rises already announced this year. Such fare increases will further hit the Kenya tourist industry.

10.5. Table 10.1 shows that total imports of crude petroleum fell by 7 per cent, from 2.55 million tonnes in 1977 to 2.37 million tonnes in 1978 while their value decreased by 8 per cent from K£100.16 million in 1977 to K£92.34 million in 1978 indicating a fall in the unit price of K£0.3 per tonne from K£39.3 per tonne in 1977 to K£39 per tonne in 1978. As a result of technical problems at the Mombasa oil refinery in the first part of 1978 imports of refined fuels increased from 105,000 tonnes valued at K£8.27 million in 1977 to 258,000 tonnes worth K£16.90 million in 1978. On the whole the total bill for imports of oil products went up from K£115.42 million in 1977 to K£115.95 million in 1978.

10.6. The fall in coffee prices on the international market affected the foreign exchange position of Kenya's export markets for its oil products. The share of exports to Uganda which suffered a critical shortage of foreign exchange, dropped significantly from 28 per cent of the total of Kenya's exports of oil products in 1977, to 22 per cent in 1978. There was also decline, though of a lesser significance, in exports to Rwanda, Burundi and Zaire. Sales for ships bunkering too fell. As a result both the total quantity and value of petroleum products exported to all destinations declined by 14 per cent from 1,365,000 tonnes in 1977 to only 1,173,300 tonnes in 1978. There was a corresponding drop of 17 per cent in value of exports of all oil products from K£83 million in 1977 to about K£69 million in 1978. There has been a consistent decline in the value of exports of oil products from Kenya since 1973. The net cost of oil products has as a result risen from K£1.1 million in 1973, to K£48.9 million in 1978. It seems likely that the net deficit will rise further in 1979.

10.7. The trade in oil products is not the only major cause of instability in Kenya's balance of payments on its external merchandise account. It is, however, a contributory factor to the widening of the deficit in the current account of its balance of payments since 1973. Kenya has had an average

Table 10.1

QUANTITY AND VALUE OF IMPORTS AND EXPORTS OF PETROLEUM PRODUCTS, 1974–1978

	1974		1975		1976		1977		1978	
	Quantity '000 tonnes	Value K£'000	Quantity '000 tonnes	Value K£'000	Quantity '000 tonnes	Value K£'000	Quantity '000 tonnes	Value K£'000	Quantity '000 tonnes	Value K£'000
IMPORTS—										
Crude Petroleum	2,902·9	67,027·0	2,824·9	88,832·4	2,496·7	93,469·5	2,551·5	100,155·4	2,369·2	92,337·4
Petroleum Fuels	129·9	6,279·7	16·7	1,249·1	47·7	3,345·7	104·7	8,269·9	258·3	16,499·4
Lubricating oils	100·5	6,885·4	77·6	4,155·1	53·0	5,678·9	73·9	6,927·7	65·4	6,638·1
Lubricating greases	0·4	85·9	0·3	73·7	0·1	41·5	0·2	65·1	0·2	73·2
TOTAL	3,133·7	80,288·0	2,919·5	94,343·3	2,597·5	102,535·6	2,730·0	115,421·1	2,693·1	115,948·3
EXPORTS—										
Petroleum Fuels	1,588·7	37,881·2	1,318·1	45,988·4	1,372·0	57,660·4	1,365·0	72,398·1	1,172·3	60,377·9
Lubricating oils	60·4	6,728·5	37·3	8,670·7	37·3	10,584·7	50·0	10,251·8	38·9	8,172·2
Lubricating greases	2·7	409·8	2·2	478·7	1·5	372·2	1·5	350·3	1·3	378·7
TOTAL	1,651·8	45,178·8	1,377·9	55,137·4	1,410·8	68,560·3	1,416·5	83,002·4	1,212·5	68,921·3

deficit of K£39 million per annum, on trade in oil products, between 1974 and 1978. This is an equivalent of 31 per cent of the total annual average deficit of K£126 million on merchandise account.

10.8. Prior to 1973 the refinery at Mombasa exported about 55 per cent of its output at prices which helped cover the production costs of the refinery. The relative decline in importance of the export markets is only partly due to higher domestic demand and can mainly be attributed to changed trading conditions in these export markets. As a result exports in 1978 were down to 41.4 per cent of the output of the refinery. This has had a big impact on the net cost of consumption of oil products in Kenya. The decline in exports of the oil refinery products as shown below has been a consistent one and it seems that this trend of a decline in the relative proportion of exports is likely to continue, as a result of the 15 per cent rise in oil prices announced by OPEC in the first part of 1979.

Sales of Mombasa Oil Refinery Products

	Domestic Demand	Exports	Per cent Total
1973	45·7	54·3	100·0
1974	46·0	54·0	100·0
1975	51·4	48·6	100·0
1976	53·3	46·7	100·0
1977	54·1	45·9	100·0
1978	58·6	41·4	100·0

10.9. Table 10.2 details the changes in wholesale prices of petroleum products at Mombasa from September 1973 to April, 1979. As noted the price of industrial diesel oil in 1979 at K.Sh. 1,585 per tonne was 3.4 times higher than the price of K.Sh. 471 in 1973. With the exception of liquified

WHOLESALE PRICES OF PETROLEUM PRODUCTS AT MOMBASA, ON 30TH SEPTEMBER, 1973, 31ST DECEMBER, 1976 3RD SEPTEMBER, 1977, 16TH JUNE, 1978 AND 8TH APRIL, 1979

Table 10.2 — K.Sh. per tonne

	30-9-1973	31-12-1976	3-9-1977	16-6-1978	8-4-1979	Ratio 1979/73
L.P.G.*	2,060	2,980	3,100	3,120	3,374	163·8
Premium motor gasoline ..	1,551	3,198	3,569	3,729	4,180	269·5
Regular motor gasoline ..	1,468	3,311	3,515	3,679	4,001	272·5
Illuminating kerosene ..	736	1,384	1,689	1,711	1,902	258·4
Power kerosene: blended ..	763	1,902	2,206	2,266	2,496	327·1
Light diesel oil	892	1,873	2,079	2,319	2,433	272·8
Industrial diesel oil	471	1,295	1,395	1,415	1,585	336·5
Fuel oil	334	796	875	891	1,045	312·9

*Liquified petroleum gas

petroleum gas, whose price in 1978 was about 1.6 times that of 1973, the prices of rest of the major oil products, power kerosene, fuel oil, light diesel oil, motor gasoline, illuminating kerosene have risen by 2.6 to 3.3 times between 1973 and 1979.

10.10. As shown below retail prices of petroleum products rose only once during 1978 by 5 per cent as compared to a total rise of 13 per cent in 1977. There were further increases of 8.6 to 11.5 per cent in April 1979. The world market for crude petroleum continues to be influenced by political events and while it is difficult to be precise about the immediate outlook, the long-term trend in prices seems likely to continue upwards. Many countries have already adopted policies to economise on consumption of petroleum products and it is hoped that these measures can begin to have some impact on total demand thus reducing the effect of market influences as a factor leading to increased prices.

Nairobi Retail Prices since 1974

K.Sh. per tonne

Date	*Premium Motor Spirit*	*Regular Motor Spirit*	*Gas Oil*
12-4-74	2,211·30	2,104·50	1,381·56
12-5-74	2,347·80	2,244·80	1,500·66
16-6-74	2,620·80	2,525·40	1,500·66
20-3-75	2,770·95	2,679·73	1,619·76
13-6-75	3,098·55	3,016·45	1,750·77
6-12-75	3,371·55	3,297·05	1,988·97
10-3-76	3,508·05	3,437·35	2,108·07
14-4-77	3,603·60	3,535·56	2,191·44
19-6-77	3,876·60	3,816·16	2,310·54
3-9-77	3,944·85	3,886·31	2,393·91
16-6-78	4,135·95	4,082·73	2,513·01
8-4-79	4,613·70	4,433·48	2,751·21

Oil Refinery: Throughput and Output of Finished Petroleum Products*, 1974–1978

Table 10.3

'000 *tonnes*

	1974	1975	1976	1977	1978
Crude petroleum throughput ..	2,840·5	2,837·5	2,574·8	2,570·2	2,584·7
Output—					
L.P.G.**	17·3	17·7	19·2	19·4	19·3
Motor gasoline: premium ..	196·9	211·4	228·9	221·3	241·8
Motor gasoline: regular ..	160·0	140·0	122·5	144·8	136·0
Illuminating kerosene ..	72·4	47·2	422·0	376·6	286·0
Jet/turbo fuel	302·8	424·7			
Light diesel oil	406·6	396·1	395·5	446·9	468·5
Heavy diesel oil	56·6	51·2	104·0	106·2	81·7
Marine diesel oil	100·2	90·6			
Fuel oil..	900·4	896·7	852·9	832·9	746·1
Export residues	476·6	411·9	283·8	276·4	366·5
Bitumen	25·6	40·7	42·2	34·0	22·1
Intermediates	—	−5·1	−3·3	—	−5·3
Refinery usage..	114·1	114·3	107·0	111·6	122·0
Total Output	2,840·5	2,837·5	2,574·8	2,570·2	2,584·7

*Excludes lubricants.

**Liquified petroleum gas.

10.11. Table 10.3 indicates that the total volume of refinery throughput has fallen by 9 per cent since 1974. The fall actually occurred in 1976 but since then the throughput has been stable and the Mombasa refinery has been working at 65 per cent of its operational capacity. Present plans do not envisage any increase in capacity but yields should be improved as a computerised process supervisory system and a secondary processing unit become operational. The largest fall in production since 1974 has occurred in the output of fuel oil and export residues which are the cheaper products. Output of motor gasoline and lighter diesel oil has increased while production of illuminating kerosene and jet fuel, has risen slightly despite the substantial falls in 1976 and 1977.

10.12. Sales of petroleum products for domestic consumption, as shown in Table 10.4 rose by 2 per cent from 1,502,900 tonnes in 1977 to 1,537,900 tonnes in 1978. There has been a consistent upward trend in domestic

Petroleum Supply and Demand Balance, 1974–1978

Table 10.4

'000 *tonnes*

	1974	1975	1976	1977	1978
Demand—					
L.P.G.	12·4	13·7	14·7	16·1	17·3
Motor spirit premium and regular	225·7	234·8	241·0	270·5	290·5
Aviation spirit..	5·6	6·0	5·7	6·2	6·5
Jet turbo fuel*..	238·9	282·4	305·2	290·0	328·0
Illuminating kerosene ..	53·1	55·4	53·2	64·3	78·0
Power kerosene	1·5	0·2	0·2	0·2	0·2
Light diesel oil	250·1	255·0	288·3	305·4	244·2
Heavy diesel oil	40·4	32·8	44·7	32·6	29·0
Fuel oil..	412·0	398·2	503·3	517·6	443·9
Total	1,238·6	1,278·5	1,456·5	1,502·9	1,537·9
Refinery usage..	114·1	114·3	107·0	101·0	122·0
Total Domestic Demand ..	1,352·7	1,392·8	1,563·5	1,603·9	1,659·9
Exports of Petroleum fuels ..	1,588·7	1,318·1	1,472·0	1,171·8	1,173·3
Total Demand ..	2,941·4	2,710·9	2,935·5	2,970·9	2,833·2
Supply—					
Imports:					
Crude oil	2,902·9	2,824·9	2,496·7	2,551·5	2,369·2
Petroleum fuels	129·9	16·7	47·7	104·7	258·3
Total	3,032·8	2,841·6	2,544·4	2,656·2	2,627·5
Adjustment**	−91·4	−130·7	391·1	314·7	205·7
Total Supply	2,941·4	2,710·9	2,935·5	2,970·9	2,833·2

*Includes sales to foreign airlines at airports in Kenya.

**Adjustment for inventory changes and losses in production.

consumption of petroleum products since 1974. The total domestic sales of petroleum products in 1978 was 24 per cent higher than in 1974. Total sales will be influenced in the current plan period by the Government's intention to introduce ways and means of conserving energy. This should have a particular impact on the growth in the use of petroleum products which as already indicated is a potent source of balance of payments problems.

10.13. Most of the increase in consumption in 1978 occurred in sales of motor spirit, jet fuel, illuminating kerosene and light diesel oil, while there was a decline of nearly 10 per cent in sales of fuel oil reversing the trend of increased sales which had been prevalent since 1975. The most significant increases were recorded in sales of lighting kerosene and jet fuel. The volume of sales of these two products rose by 21 and 13 per cent respectively. The shortage of charcoal which had occurred in 1977 and led to rises in its prices continued into 1978. This accounts for the increase in sales of kerosene which has been adopted as substitute fuel especially by low income householders. The rise in sales of jet fuel can be accounted for by the opening of Mombasa airport to international airlines on direct flights from other areas of the world. Sales of motor spirit have risen by 29 per cent since 1974 with particular significant rises of 12.2 and 7.5 per cent being recorded in 1977 and 1978 respectively. Sales of light diesel fuel have similarly increased by nearly 30 per cent since 1974 with substantial rises being also recorded between 1976 and 1978. The overall petroleum supply and demand balance sheet given in Table 10.4 illustrates the trends in domestic consumption and exports of petroleum products and their net effect on total demand, which in 1978 was reduced by 4.6 per cent.

Electricity

10.14. Hydro-electricity together with fuelwood and charcoal are the only primary domestic sources of energy. The geothermal plant, now under construction, when commissioned in mid-1981 will be the other major source.

INSTALLED CAPACITY AND GENERATION OF ELECTRICITY, 1974–1978

Table 10.5

	Installed Capacity* MW**			Generation* GWH†		
	Hydro	Thermal	Total	Hydro	Thermal	Total
1974	139·1	145·1	284·1	547·1	322·6	869·7
1975	139·1	144·0	283·1	649·1	322·2	971·2
1976	171·4	181·7	353·1	583·2	574·7	1,157·9
1977	173·5	182·9	356·4	749·3	364·0	1,113·3
1978	311·5	171·6	483·1	1,072·8	308·9	1,381·7

*Includes estimates for industrial establishments with generation capacity.

**1 megawatt = 1 million watts = 1,000 Kilowatts.

†1 gigawatt hour = 1,000,000 kilowatt hours.

Table 10.5 indicates that the total installed generating capacity for hydro and thermal electricity rose by 35 per cent from 356.4 MW in 1977 to 483.1 MW in 1978. The bulk of the increase in 1978 is accounted for by the commissioning of 145 MW hydro generation capacity at Gitaru in July, 1978. Additional capacity to generate a further 40 MW of hydro and 30 MW of geothermal electricity—raising the level of total capacity to 550 MW, is expected to be commissioned in 1982 and 1983, respectively. In the long run, as per the figures detailed below the increase in supply of electricity to meet the anticipated high growth in demand is scheduled to be secured by harnessing the country's potential for hydro electricity and thereafter increasingly by making use of the geothermal resources.

Projected Supply Potential and Demand, 1983-2000(Megawatts)

	1983	1988	1993	2000
Hydro	600	600	600	600
Geothermal	30	170	500	500
Total supply potential ..	630	770	1,000	1,100
Projected demand	362	517	747	1,267
Surplus/deficit	268	253	353	—167

10.15. Although variations in rainfall have had some impact on hydro-electricity generated, the growth in output since 1974 has generally been related to the additions to capacity. The amount of hydro-electricity generated, rose from 407.7 Gwh in 1973 to 649.1 Gwh in 1975 and then dropped to 583.2 Gwh in 1976 due to drought during that year. Good rainfall in 1977 and the additional capacity installed in 1976 raised output to 749.3 Kwh in 1977 to be boosted still further in 1978 by the additional capacity that came on stream in the middle of that year. As a result while the total of electricity generated rose by 24 per cent from 1,113.3 Gwh in 1977 to 1,381.9 Gwh in 1978, the volume of hydro power generated increased by 43 per cent as compared to a rise of 28 per cent between 1976 and 1977. Consequently despite the drop in generation of the thermal power, the proportion of electricity generated domestically has risen from 82 per cent in 1976 to 86 per cent in 1978.

10.16. Table 10.6 indicates that total consumption of electricity rose from 995 million Kwh in 1974 to 1,370.5 million Kwh in 1978, an increase of 37.7 per cent, at an average rate of 7.6 per cent per annum. The highest percentage increase was recorded in consumption of electricity for domestic use which rose by 60 per cent from 205.6 million Kwh in 1974 to 328.5 million Kwh in 1978. Demand for industrial use rose by 33 per cent from 532.7 million to 710.4 million Kwh during this period while consumption by commercial and light industrial enterprises increased by 30 per cent from 246.6 million Kwh in 1974 to 321.2 million Kwh in 1978.

ELECTRICITY ENERGY SUPPLY AND DEMAND BALANCE, 1974-1978

Table 10.6

GWH

	1974	1975	1976	1977	1978
DEMAND—					
Residential	205·6	300·9	300·1	303·5	328·5
Commercial and light Industrial	246·6	263·3	272·9	301·2	321·2
Industrial	532·7	496·6	568·9	658·1	710·4
Street Lighting	10·1	10·7	10·6	10·8	10·4
TOTAL	995·0	1,071·5	1,152·5	1,273·6	1,370·5
Transmission losses and unallocated demand ..	144·7	121·1	196·6	83·7	203·2
TOTAL DEMAND=TOTAL SUPPLY	1,139·7	1,192·6	1,322·1	1,357·3	1,573·7
Of which imports*	256·0	260·8	241·9	271·8	217·0
Net generation	843·8	931·8	1,080·2	1,085·5	1,356·7

*Imports from Uganda.

10.17. The development in generating capacity for electricity has been undertaken in anticipation of the potential demand which is expected to be high. A new power station was commissioned at Marsabit in 1978 and the power station in Mandera was nearing completion. In addition work on extension of supply to Isiolo and Vihiga is nearing completion. The Government plans to spend an estimated K£4.2 million on rural electrification during the current plan period.

Energy Balance

10.18. Table 10.7 gives figures on usage of energy in the modern sector of the economy in terms of oil equivalent. As shown Kenya's modern sector relies heavily on imported energy. The proportion of energy production from hydro power has been increasing but in 1978 it still accounted for only 12.8 per cent of total consumption although this is a substantial rise from the 8.2 per cent recorded in 1974. The proportion of energy generated from domestic resources is, however, expected to rise substatially in future years as both hydro and geothermal energy sources are tapped.

Energy Policy

10.19. The National Council of Science and Technology has set up a committee to advise the Government on a suitable energy policy for the country. Since the oil crisis of December, 1973, high prices of oil have continued to impede economic development. A satisfactory energy policy will, it is hoped, play a part in resolving the problems which dependence on imported sources of energy create. Meanwhile the modern sector of economy

will continue to rely heavily on oil. Various interim measures are being taken to curtail some of the adverse effects which reliance on oil has had on the country's balance of payments position. The refinery at Mombasa is being made more efficient to improve its output/input ratios. Further measures are being considered to make the distribution of oil products more efficient and economise in their use. Production of power alcohol from sugar cane for blending with motor gasoline is being initiated, and this could result in some reduction in imports of crude oil from abroad although it has been projected that demand for oil products will grow at a rate of 5.8 per cent per annum during the current plan period. The greater use of common transport services such as the railways, the oil pipeline and other means of public transport as distinct from private transport should also yield economies in consumption of oil products.

PRODUCTION, TRADE AND CONSUMPTION OF ENERGY EXPRESSED IN TERMS OF THE PRIMARY SOURCES, 1974–1978

Table 10.7

'000 *Tonnes Oil Equivalent*

	1974	1975	1976	1977	1978
COAL AND COKE IMPORTS ..	46·6	32·1	44·9	43·8	34·8
OIL—					
Imports of crude oil ..	2,902·9	2,824·9	2,496·7	2,551·5	2,369·2
Net exports of petroleum fuels	−1,458·8	−1,301·4	−1,324·3	−1,260·3	−1,195·9
Stock changes and balancing item	−91·4	−130·7	391·1	314·7	486·6
TOTAL CONSUMPTION OF LIQUID FUELS	1,352·7	1,392·8	1,563·5	1,605·9	1,659·9
HYDRO ENERGY—					
Local production of hydro-power	131·3	155·8	140·0	167·4	257·5
Imports of hydro-power ..	71·0	62·6	58·1	65·2	52·1
TOTAL CONSUMPTION OF HYDRO-ENERGY	202·3	218·4	198·1	232·6	309·8
TOTAL LOCAL ENERGY PRODUCTION	131·3	155·8	140·0	167·4	257·5
TOTAL IMPORTS	1,561·7	1,618·2	1,275·5	1,400·2	1,260·3
Use of stock and balancing item	—91·4	—130·7	391·1	314·7	486·6
TOTAL ENERGY CONSUMPTION	1,601·6	1,643·3	1,806·5	1,882·3	2,004·4
LOCAL PRODUCTION AS PERCENTAGE OF TOTAL ..	8·2	9·5	7·7	8·9	12·8
PER CAPITA CONSUMPTION IN TERMS OF KILOGRAM OF OIL EQUIVALENT	123	125	130	131	135

*Modern sector only; fuelwood and charcoal are excluded.

Energy Sector

8.120. The need to formulate comprehensive national energy development plans has become generally recognized by developed and developing countries alike in the aftermath of the 1973-74 energy crisis. The rising costs of energy supplies, and more particularly that of petroleum, have had adverse effects on the foreign exchange resources of many economies and raised costs of production. Kenya is no exception. About 85 per cent of commercially traded energy in Kenya is derived from imported petroleum. About one quarter of the nation's foreign exchange earnings is used for petroleum imports. This high dependence on foreign energy resources and the role energy plays in all economic activities necessitate high priority being accorded to the comprehensive planning of the development of the energy sector.

8.121. The rural population faces an equally severe problem due to their almost exclusive reliance on firewood. This dependency results in deforestation on a potentially catastrophic scale. Arresting this process will require a combination of programmes such as reafforestation, introduction of renewable sources of energy, and changes in the management of available wood supply. On the positive side, Kenya has made important strides in developing some of her indigenous energy sources. Over one third of the total estimated hydro-electric potential of 700 MW has already been developed. Geothermal potential is estimated at about 500 MW, with the first geothermal station producing 15 MW coming into operation in 1981.

8.122. During this plan period, the development objectives for the energy sector will be:—

i. increasing the supply of energy to meet the requirements of the economy;

ii. rationalizing the use of imported petroleum;

iii. developing indigenous energy resources; and

iv. lessening dependence on imported fuels.

Energy Consumption

8.123. The demand for energy will continue to rise with the growth of the economy. Table 8.13 indicates the overall consumption of the major forms of commercial energy during the period 1973-77 and projections for 1983. It will be observed that the consumption of petroleum fuels during the 1973-77 period grew at an annual rate of 4.2 per cent. Electricity consumption, on the other hand, rose during the same period at an annual rate of 8.1 per cent. Consumption of locally produced electricity rose from 97,900 tonnes oil

equivalent in 1973 to 140,000 tonnes oil equivalent in 1976. Imported electricity as a percentage of total electricity consumed dropped from 30 per cent in 1973 to 10 per cent in 1976. It should be noted that the share of oil out of the total energy consumed declined by 1.2 per cent during the period 1973-77 whereas the share of electricity in total energy consumed rose by 1.6 per cent. As can be seen in Table 8.13, the consumption of coal and coke, which is used mainly in industry, declined during the period at about 2.9 per cent per annum.

CONSUMPTION OF ENERGY EXPRESSED IN TERMS PRIMARY SOURCES

Table 8.13

Form of Energy	Oil Equivalent ('000 Tonnes)		Percentage Annual Rate of Increase	Per cent of Total Energy Consumed		Forecast 1983	
	1973	1977	1973–77	1973	1977	Oil Equivalent ('000 Tonnes)	Per cent share
Coal and Coke ..	50·0	43·8	−2·9	3·2	2·3	36·3	1·5
Oil	1,359·9	1,603·90	4·2	86·0	85·0	2,055·3	84·7
Electricity	170·4	232·6	8·1	10·8	12·4	339·0	13·8
TOTAL ENERGY	1,580·3	1,886·5	4·5	100·0	100·0	2,460·6	100·0
Import as percentage of total energy consumed ..	83·0	74·4					
Per Capita Consumption in terms of kg. Oil Equivalent ..	127	131					

Electricity Consumption

8.124. Total consumption of electricity over the last five years rose from 860 Gegawatt Hours (GWH) in 1973 to 1082 GWH in 1976. In view of the increased economic activity in urban and rural sectors, the demand for electricity is expected to grow at a rate of 9 per cent per annum over the next five years. In terms of Megawatts (MW), demand will increase from 200 MW in 1976 to 352 MW in 1983.

8.125. In 1976, the domestic installed generation capacity was about 295 MW. This will rise to 510 MW in 1983. The total exploitable potential of the Tana River is estimated to be 540 MW. In addition, the potential of other smaller rivers is estimated to be 230 MW. To this should be added the potential of geothermal resources, which for Olkaria alone is estimated to be about 170 MW. Table 8.14 shows the potential supply of electricity from different hydro-power and geothermal sources. From the table, it can be seen that demand for electricity at present and for the next 10-15 years can be met from available hydro and geothermal resources, if these are fully exploited.

EXPLOITABLE POWER FROM EXISTING AND POTENTIAL HYDRO* AND GEOTHERMAL RESOURCES: 1976

Table 8.14

River	Location/Power Station	Existing: Installed Capacity	Existing: Actual Average output	Planned Potential	Total Exploitable Potential
Tana	Tana/Wanjii	22	20		
	Kindaruma	44	20		
	Kamburu	84	51		
	Gitaru	145	93		
	Upper Reservoir	—	—	40	
	Kiambere	—	—	120	
	Mutonga	—	—	70	
	Grand Falls	—	—	80	
	Kurura	—	—	40	
	Adamson's Falls	—	—	50	
	Korch	—	—	80	
	Usueni	—	—	60	
	TOTAL TANA	295	184	540	835
Nzoia	Broderick Falls	—	—	10	
Yala	Kimundi Confluence	—	—	40	
Sondu	Sondu	—	—	60	
Arror	Kapsowar	—	—	20	
Turkwel	Turkwel Gorge	—	—	100	
	TOTAL OTHER RIVERS	—	—	230	230
Geothermal	Olkaria Valley	—	—	30	174
	Other Areas	—	—	0	326
	TOTAL GEOTHERMAL	—	—	30	500
TOTAL	Power	295	184	800	1,565

*Under average river-flow conditions.

Fuel Consumption

8.126. Table 8.15 indicates the consumption of petroleum fuels in 1976 and estimated for 1978 and 1983. From the table it will be observed that the rate of growth of consumption of all petroleum fuels was 7.2 per cent per annum between 1976 and 1978 as compared to 4.2 per cent per annum for the 1973-77 period. In the 1978-83 period the highest growth rate will be registered in the turbo fuel which is used by aircraft. Its consumption will

GROWTH OF DOMESTIC CONSUMPTION OF PETROLEUM FUELS

Table 8.15 — Litres 000

Fuels	1976 Actual (Demand)	1978 Estimated	Growth Rates Percentage	1983 (Forecast)
Liquefied Petroleum Gas	14,700	16,555	7·2	23,682
Motor Spirit	333,553	376,267	6·3	503,530
Aviation Spirit	8,281	10,500	12·7	19,345
Turbo Fuel	407,490	530,132	14·0	1,020,723
Lighting Kerosene	67,798	74,505	4·9	95,089
Power Kerosene	254	150	−15·8	—
Light Diesel Oil	340,806	409,033	9·5	643,999
Heavy Diesel Oil	52,811	59,182	5·8	78,454
Fuel Oil	534,012	549,719	1·5	592,207
TOTAL FUELS	1,759,705	2,026,461	7·2	—

rise from 407 million litres in 1976 to 1,001 million litres in 1983. Most of the diesel oil and motor spirit which grew at about 9.5 per cent per annum and 6.3 per cent per annum respectively, between 1976 and 1978, are forecast to rise to about 644 million litres and about 504 million litres respectively in 1983.

Wood and Charcoal Consumption

8.127. Wood and charcoal are the main sources of energy in the rural areas and in some industries. It is estimated that the annual consumption of fuel wood and charcoal is well in excess of 10 million tonnes per annum and will increase at a rate of at least 3.5 per cent per annum unless alternatives can be offered to the rural population. The programmes for the development of indigenous energy resources discussed below aim at providing these alternatives.

Development Programmes for Petroleum Fuels

8.128. Development activities in the oil industry will mainly consist of investments in the refinery, improvement in the efficiency of distribution by oil companies, expansion programmes of oil companies, rationalization of use and conservation of oil, oil exploration, and the development of power alcohol.

8.129. *Rationalization of Use of Oil.*—According to the data on consumption of petroleum fuels, 15 per cent is used in industrial and commercial enterprises; 64 per cent in transport, of which 24 per cent is in road transport, and 8 per cent in rail transport. More rational use of petroleum will be effected especially in the transport sector which consumes the largest percentage of petroleum fuels. As indicated earlier, road transport consumes more oil per freight ton hauled than rail transport. Measures to be taken, as stated in the rail-road-oil-pipeline co-ordination section, will rationalize rail-road and oil pipeline modes of transportation and have the effect of reducing oil consumption in the transport sector.

8.130. *Oil Refinery.*—The Kenya oil refinery at Mombasa has a capacity of refining 4.8 million tonnes of crude oil per annum. Throughout the plan period, the refinery will operate with excess capacity, and no expansion is, therefore, planned. However, K£810,000 will be used to install a computerized process supervisory system to improve the overall efficiency and recovery of the finished products. This, along with the secondary processing units to be installed at the refinery, will improve product yields of crude oil imports.

8.131. *Power Alcohol.*—Alcohol can be used as a substitute for petrol. Some of the sources of power alcohol which are locally available are cassava and molasses. Two enterprises for the domestic manufacture of alcohol will be implemented during this plan period. The power alcohol produced will be blended with petrol. This will result in some reduction in imports of crude oil from overseas.

8.132. *Oil Exploration.*—Approximately one third of Kenya's land area is considered geologically to have oil bearing potential. A total of K£11.0 million has been spent since 1970 by the oil companies in their search for oil. While oil discovery has been unsuccessful, the search for oil and natural gas continues. These efforts will be intensified with planned Government participation, as the importance of being able to assess, with greater certainty, the country's resource potential is clearly recognized. The development of a national energy policy requires a thorough understanding of the resource base so that development planning can take into account realistic estimates of the potential.

Development Programmes for Electricity

8.133. The completion of Gitaru Power Station has added 145 MW to the installed capacity. The Upper Reservoir (Masinga Power Station), which is being financed as a multi-purpose project costing about K£50 million, is to be completed in 1982, and will add 40 MW to the system. This will also increase the firm capacity of the existing hydro-stations during the dry periods, as the Tana River flows will be more uniformly regulated.

8.134. The construction of the next hydro station on the River Tana (at Kiambere Gorge) is scheduled to start in 1981 and to be completed by 1985. The project will cost about K£60 million and will add another 120 MW of installed capacity to the system.

8.135. A 220 kV. single-circuit transmission line will be constructed between the Tana River Hydro Station and Mombasa, to transfer the surplus hydro energy to Mombasa in order to save fuel costs on thermal generation. This transmission line, together with terminal equipment, will cost about K£16 million. Furthermore, about 250 km. of 132 kV. lines will be constructed in the Western and Mt. Kenya areas to reinforce the existing system and meet the future industrial demand in these areas.

Geothermal

8.136. In the next five to six years, further exploration of geothermal potential of the country will be carried out in areas other than Olkaria. This will involve a total capital outlay of about K£2.0 million. Exploitation of the existing potential will include the construction of one 15 MW station at Olkaria which is planned for completion in mid-1981 at a cost of some K£12 million, followed by another 15 MW station the following year at an additional cost of K£8 million.

Rural Electrification

8.137. The Rural Electrification Programme is a Government initiated scheme for the provision of electricity in rural areas. This will help develop these areas and raise the standard of living of the rural people. The programme will require an estimated K£4.2 million for the period 1979-83 compared to K£1.4 million for the period 1974-78. The selection of centres

Centres (see Chapter 2). However, priorities among the various centres will for electrification will in general support the hierarchy of Designated Service be determined on the basis of the following:—

i. main rural centres with potential customers in densely populated surrounding areas;

ii. all important administrative centres in sparsely populated areas;

iii. remaining rural centres in densely populated areas; and

iv. areas with interconnecting lines.

8.138. The rural electrification programme during the plan period comprises 48 projects. Table 8.16 indicates the number and costs of projects in each province.

RURAL ELECTRIFICATION PROJECTS, 1978/79–1982/83

Table 8.16

Province	Number of Projects	Cost K£
Central	7	810,000
Coast..	6	400,000
Eastern	14	825,000
North-Eastern	2	285,000
Nyanza	7	375,000
Rift Valley	6	945,000
Western	6	575,000
TOTAL	48	4,215,000

Electricity Tariffs

8.139. A new tariff structure which is both rational and simple was introduced by East African Power and Lighting Company with effect from 1st January, 1979. It has only 5 categories of consumers as against 7 in the old tariff structure. The categories are as follows:—

i. consumers with monthly consumption not exceeding 7,000 kWh.;

ii. consumers with monthly consumption between 7,000 and 100,000 kWh.;

iii. consumers with consumption exceeding 100,000 kWh. per month;

iv. off-peak supplies; and

v. public lighting.

8.140. Each category of consumer will be charged at a rate that reflects more closely the cost of providing the supply to that customer. Consumers under category (iii) are also offered a reduced rate for units consumed during off-peak hours. This will be possible as their electricity supply will be provided when demand is low.

Development of Indigenous Resources

8.141. To reduce dependence on imported fuels, indigenous resources of energy have to be developed. As indicated earlier, exploration findings on the geothermal fields indicate that the electrical power which can be exploited from these resources are as high as 170 MW for Olkaria. There are indications that the country has a potential of over 500 MW of geothermal energy. There will be a phased development of geothermal energy resources in the future.

8.142. Other forms of energy will be explored and developed. Afforestation programmes will be implemented to provide the required wood and charcoal fuel. Plans are underway to plant, as a pilot project, 20,000 hectares of eucalyptus species mainly for the production of fuelwood and poles in semi-arid areas during the plan period. Research on non-conventional sources of energy such as biogas, sun and wind will be intensified. Pilot projects on these forms of energy are already being implemented, mainly in the rural areas.

Institutional Arrangements

8.143. The Ministry of Power and Communications has overall responsibilities for the development of the energy sector. This includes responsibility for formulation of the energy policy. Because of its heavy responsibility in this field, it will strengthen its capacity to plan comprehensive energy development. The recently established Inter-ministerial Committee on Energy Resources, now functioning under the auspices of the National Council for Science and Technology, will be supported by an adequately staffed division in the Planning Department of the Ministry of Power and Communications.

8.144. The petroleum industry, a major component of the energy sector, is largely composed of large international oil companies which import their crude oil supplies. The crude oil is refined at a fee, and the refined products are then distributed throughout the country. The companies will, during this plan period, be called upon to co-operate in implementing proposals described earlier to transport oil by rail to centres north and west of Nairobi. The implementation of this distribution programme will necessitate oil depots being constructed at selected terminals along the railways network and at Malaba for storage of oil to be exported to countries to the West of Kenya.

8.145. The Kenya Power Company and the Tana River Development Company, whose main functions are the development of resources for the generation of electricity, will investigate other power resource potentials from both hydro and geothermal sources. In performing this function, they will collaborate with such organizations as the Tana River Development Authority and the East African Power and Lighting Company, the main distributor of electricity. Kenya is one of the countries with the highest prices for electricity.

This may limit the use of electricity as a major form of energy. All organizations engaged in the generation and distribution of power will, therefore, be required to effect efficiency in production and distribution so as to lower these costs and thus cheapen the price of power.

Conservation of Energy

8.146. In the past, insufficient attention has been given to the subject of conservation of energy. As a developing country, the prospects are that the use of energy will increase, particularly in the commercial and industrial sectors. To make the best use of the limited energy resources, the following measures will be taken. Firstly, most of the imported fuels are consumed in the transport industry. In order to save on fuel in this sector, emphasis will be put on encouraging the use of public transport as opposed to private transport. Secondly, the energy use/output ratio will be improved by all users of energy. The public, through the mass media, will be educated on energy conservation techniques. Thirdly, afforestation programmes will be speeded up particularly in the semi-arid areas. Fourthly, other fiscal measures will be introduced to help rationalize the use of imported fuels.

Environmental Impacts

8.147. The generation and use of energy often has adverse environmental effects which should be avoided. Smoke and fumes from factories, houses and vehicles cause air pollution which affects the ecological patterns of an area. The construction of dams for electricity generation changes the pattern of the aquatic life downstream and the ecological balance in the surrounding areas. The development of geothermal resources for electricity development produces poisonous gases, effluent water and noise. The uncontrolled felling of trees for charcoal burning produces pollution, desertification and soil erosion. All of these factors will be considered before different forms of energy are developed or exploited. During the plan period, standards will be prescribed that will be observed by all enterprises that generate and transport or transmit energy. Existing anti-pollution laws will be strictly implemented. Environmental Impact Reports will be required before new projects are approved (*see* Chapter 2).

Ministry of Power and Communication Forward Budgets

8.148. The development and recurrent expenditure forward budget for the Ministry of Power and Communications are shown in Tables 8.17 and 8.18 respectively. Development expenditures cover all the corporations and departments under the Ministry. However, although the development expenditures of the self-financing corporations are shown in the table, they are not included in the total of the allocations to the Ministry. The self-financing corporations are Harbours, Posts and Telecommunications, and Kenextel. The allocation to Kenya Railways amounting to K£31.75 million includes K£26.75 million which is part of the funds already passed on to the Corporation for the purchase of locomotives and wagons.

APPENDIX D

SCOPE OR WORK
FOR AN
IQC OR REQUIREMENTS CONTRACTOR
(1) USAID/KENYA RENEWABLE ENERGY DEVELOPMENT PROJECT (615-0205)
AND
(2) AFFORESTATION AND TREE NURSERIES FEASIBILITY STUDY PROJECT (615-0172)

This document contains scopes of work for two AID financed studies in Kenya: (1) Renewable Energy Development Project (615-0205) and (2) Afforestation and Tree Nurseries Feasibility Study Project (615-0172). The two studies should be carried out by one consulting firm because some components such as nurseries for fuelwood and woodlots program under Project (1) will be very similar and related to the requirements of Project (2). Moreover, the use of some of the same personnel required for the project study (1) on the project study (2) will avoid duplication of effort and otherwise result in efficiencies.

1. RENEWABLE ENERGY DEVELOPMENT PROJECT:

I. INTRODUCTION:

The Government of Kenya (GOK) and USAID/Kenya are considering undertaking a renewable and non-conventional energy development project, with particular emphasis on the energy needs of rural Kenya. The U.S. contractor will be required to assist the GOK and USAID/Kenya in articulating the project purpose and outputs and identifying the project inputs. The study must be sufficiently complete to permit the GOK and AID to make their own independent appraisals of the project's soundness on the basis of data collected and recommendation made. The final report prepared by the contractor shall be in the form of an AID "Project Paper" (guidelines for a Project Paper are set forth in Handbook 3). It is presumed that this project Paper will support a GOK request for AID funding of the project, with funding in FY 1980 or 1981, depending on availability of funds, envisioned.

Before arrival of the contractor's team in Kenya, 3 to 4 members of the team (including the team leader) shall attend a 3 to 4 day workshop to be held in Washington, D.C. in June 1980 to provide participants from AID and the GOK with a demonstration of the computerized "AL-EDIS" energy planning information system developed by the Institute for Energy Research (IER), The State University of New York, Stony Brook. Given the incomplete state of both Kenya's energy data and the AL-EDIS system, the workshop would not be intended to provide a comprehensive energy plan for Kenya. Instead, the intent would be to:

- flag the key energy issues likely to face Kenya in the future;
- indicate in general the energy implications of alternative policies which the GOK may consider, and,
- show major information gaps which will have to be filled before more conclusive answers to these questions are possible.

The Beijer Institute of Stockholm has financed the preparation of a scope of work for a system study of the fuelwood cycle in Kenya, which will be carried out in association with the Government of Kenya. The team preparing this scope of work plans to have a draft available by March 10, 1980, which will be reviewed at the Beijer Institute on 24-25 March, 1980. Detailed comments will be taken at this meeting for incorporation into the final scope to be prepared by June 1980. The study team should become familiar with this scope of work. The Beijer Institute has energy data on Kenya available in its library which is available for use by the study team. Some team members may find it useful to review this material en route to Kenya.

II. SCOPE OF SERVICES:

The contractor should refer to the attached AID's Project Identification Document (PID) and AID/W's review comments for project statement, background, energy policy considerations, intended project beneficiaries, suggested project component summary, and tentative project issues.

The required study shall contain, but not be limited to, evaluation, analyses, findings and recommendations, as appropriate, of the following project components.

(A) Initial Planing and Surveys:

The study shall identify the need for long and short-term technical assistance, training of GOK officials and commodities toward the following objectives: (i) development of Ministry of Energy (MOE) capability in executing surveys of rural and urban energy needs, in such categories as fuelwood charcoal, electricity, etc; (ii) review and comment on the draft scope of work prepared by the Beijer Institute, Stockholm, for a fuelwood supply/demand study; (iii) assistance to MOE in formulating energy policy; (iv) refinement of the IER "AL-EDIS" program for the Kenya - specific situation; and (v) establishment of an Energy Data Bank and Library in Kenya.

(B) Institutional Development:

The study shall: (i) evaluate MOE's capabilities to formulate energy plans, and policies, and to provide technical services to GOK's ministries, local governments and institutions in the area of renewable energy. In particular, identify MOE needs for long and short-term technical assistance, training and commodities in the following areas:

(a) Policy formulation;

(b) Organization, administration and staffing

(c) Planning and evaluation, and

(d) Technical services.

As regards formulation of energy policies, identify, to the extent possible, areas which are critical and can be implemented immediately and those which require further studies. For the latter, recommend appropriate procedures for undertaking the studies.

(ii) consider and make recommendations concerning appropriate linkages between MOE and other Kenya bodies (including but not limited to the National Council for Science and Technilogy, the Ministry of Works, the Ministry of Housing and Social Services, the National Environmental Secretariat and the Ministry of Environmental and Natural Resources). Identify levels and types of assistance, if any, needed to develop and enhance such linkages.

(iii) evaluate and identify technical assistance, training and commodities required by the Forestry Department of the Ministry of Environment and Natural Resources for reforestation and agroforestry programs throughout Kenya, including Arid and Semi-Arid areas with emphasis on fuelwood and soil conservation. Specific objectives concerning this aspect of the study will be to:

(a) Formulate procedures and systems, including organization and management, suitable for program needs.

(b) Recommend plans for development of nurseries, and distribution of seedlings.

(c) Outline a nursery research program, aimed at improved species for attaining goals in fuelwood and soil and water conservation.

(d) Design a forestry information and monitoring system as a management tool for evaluating progress and assessing costs.

(C) Applied Research and Demonostration:

Identify, on the basis of available information, appropriate renewable energy technologies applicable to the needs of the rural and urban poor and having promising cost/benefit ratios under Kenyan conditions. Identify most suitable organization(s) and locations for undertaking, if necessary, further applied research in, and/or demonstration of, various renewable and non-conventional energy resources. Evaluate the need for technical assistance, training and commodities; identify most serious problems with appropriate and applicable technologies. Emphasis in all research categories will be on rural areas of Kenya, but will also include alternative energy needs of

low-income urban dwellers. The specific objective is to demonstrate and evaluate effectiveness of some (say, three to four which have been rank-ordered as noted under Section G, Economic Analysis of this Scope of Work), of the following technologies which are considered most suitable in the socio-economic structure, climatic conditions, and cultural practices in Kenya:

(a) Village/household level reforestation and agroforestry.
(b) Wood and charcoal stoves; charcoal kilns.
(c) Biomass/Biogas for rural areas; small-scale alcohol, medium-scale methane.
(d) Solar energy devices for water heaters, crop driers, etc.
(e) Water pumping systems such as windmills, solar cell and hand pumps.
(f) Food processing systems such as grain grinders.
(g) Small-scale electricity for clinics, school and other rural services.

2. Review with MOE the role of the proposed Energy Research and Development Institute. Prepare Scope of Work for the detailed planning of Institute, inlcuding questions or organization, staffing and term of reference, together with order-of-magintude cost estimates.

3. Evaluate the need for technical assistance and training to develop capabilities of the Ministry of Works and the Ministry of Social Services and Housing in designing, in collaboration with the MOE, energy efficient Government buildings and housing.

4. Review with MOE and the National Council for Science and Technology proposals for establishment of a Rural Energy Bank and offer general findings and recommendations on the need for establishing such a Bank, whether as a new institution or as a new "window" at an existing institution.

(D) Monitoring and Evaluation:

1. Recommend methodology and prepare scope of work for two independent evaluations of the Renewable Energy Development Project as follows:

(i) interim report, 18 months after the activity starts and

(ii) final report.

2. Identify baseline date to be collected and recommend appropriate GOK organization for collecting such baseline data and monitoring project effectiveness.

(E) General:

1. The contractor shall evaluate and recommend the most appropriate approach to "Project Issues" identified in the PID, in AID/W's comments on that PID, and other issues about which the team becomes cognizant during the course of the study.

2. The contractor shall provide detailed scope of work for the technical assistance elements of the proposed project, including details of qualifications and duties for each technician.

3. The contractor shall provide detailed specifications for all commodities proposed for procurement in furtherance of project objectives. The contractor shall, to the extent possible, identify at least three possible sources (suppliers) of commodities, and in cases where the source and origin of the commodity must be other than U.S. or Kenya, the contractor shall prepare justification for such purchases, following consultation with USAID/Kenya.

4. The contractor shall prepare training plans and identify locations for the training (long and short-term) of GOK officials.

(F) Financial Analysis:

The contractor shall:

1. Prepare detailed cost estimate for the proposed project broken out into the four proposed components identified above. Cost schedules should show U.S. dollar costs and local currency costs for each item and should include all costs (to be financed by GOK and AID) related to the proposed project such as transportation, technicians, housing, allowances, GOK support, counterparts etc.

2. Prepare a cash disbursement schedule indicating biannual U.S. dollar and local currency requirements.

(G) Economic Analysis:

The contractor shall prepare a comprehensive Economic Analysis on a cost effective basis consistent with Handbook 3 guidance, to include:

1. A macroeconomic overview of the project, taking the following factors into account:

-- role of energy in the Kenya economy;

-- identification of the need for the project;

-- future demand for energy (conventional and non-conventional);

— estimate of additional energy demand likely to be generated as a result of the project (changes in consumption, new users, different types of users);

— additional investments which could be made (by GOK, other donors or private sector) which will complement the project;

— estimate of arresting soil erosion and depletion of forests;

— project impact on GOK's development goals, particularly on income, employment, regional development, income generation, agricultural production including agroforestry, health and general welfare;

— recurrent cost implications of the project for the GOK budget and community resources should be identified, quantified, and analyzed.

2. The economic analysis must be made based on the assumption that some of the technologies to be demonstrated under the Applied Research and Demonstration component of the proposed project will be introduced, after sufficient development, on a much wider scale in Kenya, especially in rural areas. In particular, the analysis should:

(a) Identify and quantify (where possible) the direct, indirect and external costs and benefits of the project. Costing should be done on market prices and economic prices (if appropriate) with any deviation from market prices explained and defended.

(b) The allocation of potential benefits between different beneficiaries must be identified and discussed, indicating benefit shares accuring to different economic and social groups.

(c) Energy systems to be recommended for field testing will first be appraised on the basis of benefit/cost analysis, using Kenyan cost data and shadow prices, where warranted. See "Economic Analysis of Renewable Energy Systems" by David French (AFR/DR/SDP) for examples of the methodology to be used.

(d) Based on the foregoing economic analysis and other socio-economic factors (with all assumptions fully expalined and defended), prepare a priority ranking for technologies which should be further developed under the Applied Research and Demonstration component of the proposed project for wider application in Kenya.

(e) The cost effectiveness of the project must be demonstrated and should be compared with reasonable alternatives. The design choice must be justified against reasonable alternative design for different scale, timing, or approach.

(H) Implementation Plan:

Prepare an implementation plan for the project identifying the implementation and monitoring responsibilities of Government of Kenya (MOE and other ministries) and USAID/Kenya. Describe in detail how the project should be implemented, e.g., procurement of technical assistance, and commodities, and participant traning. Identify constraints, such as GOK/AID policies, administration procedures and personnel, which may have an impact on the implementation of the project.

Prepare an implementation schedule for the project, taking into account lead times to procure commodities and technical services and to initiate training programs*. The schedule should show approximate dates when various activities related to the project should commence and end.

(I) Environmental Analysis:

1. An Initial Environment Examination report for the project has been prepared recommending "a negative determination", i.e., that an environmental analysis or impact statement is not necessary bacause AID believes that the project concentrates on institutional development studies, pilot projects and the like; and does not include any major physical interventions which would have significant impact on Kenya's physical, socio-economic or cultural environment. However, during the study if the consultants conclude that the project as a whole or a component of the project would have significant impact on Kenya's environment, then the consultants should analysis and explain the impacts. The design of the project should be such that the environmental impact of the project is minimized, or made benign exclusively.

2. The consultant should recommend procedures and technical assistance and training needed to monitor and evaluate environmental impacts of various technologies proposed for further development under the project.

III. CONSULTANT'S TEAM:

1. The consultant's team should consist of the following technicians with estimated level of effort for each technician as noted: Personnel requirements for both Study 1 (Renewable Energy) and Study 2 (Afforestation and Tree Nurseries) are incorporated below:

(a) One Energy Planner - 3 months in Kenya, and ½ month in the U.S.

(b) One Solar Energy Advisor - 1 month in Kenya.

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*Training nominations, for U.S. academic institutions, must be received six months in advance of the commencement of such training.

(c) One Wind-power Energy Advisor - 1 month in Kenya.

(d) One Energy Economist - 3 months in Kenya, and ½ month in the U.S.

(e) Two Forestry Experts - Silviculture Expert - 3 months in Kenya, and ½ month in the U.S. One Nursery Expert - 3 months in Kenya.

(f) One Public Administrator/Training Advisor - 1½ month in Kenya.

(g) One Anthropologist - 2 months in Kenya, (preferably Kenyan or resident of Kenya).

Total - 19 person months. Add contingency 1 p.m. = 20 p.m.

2. Each technician should have broad experience in renewable and non-conventional energy technologies. He/she should have at least three years' experience in his/her field of expertise and must be qualified to respond to the scope of services. He/she must have worked a minimum of six months in a developing country, preferably in an African country, on a related project. Note: The anthropologist must have a minimum of six months' experience in Kenya.

3. One of the team members, preferably, the Energy Planner, should be designated as a team leader. The team leader should have experience in preparing designs of projects financed by AID and he/she should be fully versed with the AID's requirements for a Project Paper as set forth in AID Handbook 3. The team leader should be present in Kenya during the full study period.

4. The period of assignment for each team member specified in Paragraph 1 above is an estimate. The consultant may recommend changes, based on consultant's prior experience on a similar type of project, for AID's consideration.

Moreover, during the progress of the study, if the consultant's team leader believes that a change(s) should be made in the assignment period of a technician(s) to successfully complete the study, the team leader should at once advise in writing to USAID/Kenya of the change(s) necessary explaining in detail reasons for proposing the change(s).

IV. REPORTS:

1. Report Format:

The body of the report, consisting of the major subjects included in Section II, Scope of Services, shall be prefaced by a summary which shall provide an overview of the proposed project. The summary shall present briefly, the Consultant's major findings and conclusions relative to the technical, social, economic, and environmental soundness of project.

Statistical data, calculation sheets, economic projections, detailed specifications for commodities and scope of work for technical services to be procured for the project, etc., shall be bound as appendices to the body of the report, if more convenient, bound separately.

The Report shall also recommend particular activities, with stated selection criteria, for implementation under the Applied Research and Demonstration component of the project. These recommendations shall be accompanied by estimated costs and source data and, to the extent practical, by preliminary specifications.

2. Report Submission:

The Consultant, working in coordination with USAID and the GOK, will be prepared to issue a draft of the Project Paper within six weeks of the commencement of field work in Kenya. The draft shall be submitted in five (5) copies each to the Ministry of Energy and USAID/Nairobi for review and comment. Consultant shall allow USAID and GOK three working days to read and provide preliminary comment on this draft report. Thereafter, the Consultant will undertake, during the remaining time if its personnel in Kenya, to elaborate on or advise the draft Project Paper to the extent reasonably requested by USAID/GOK. The objective in this regard is that all parties will cooperate fully toward production no later than early September 1980 of a Project Paper which could be approved for AID funding.

3. Report Language

All report and correspondence relative to this contract shall be in the English Language.

V. RESPONSIBILITIES:

1. The team shall work in close consultation with the Ministry of Energy (and other Ministries and Institutions through MOE) and with USAID/Kenya, retaining, however, full responsibility for all findings and recommendations. The MOE and USAID shall provide to the Consultant or assist the Consultant obtaining copies of all available reports, data, etc., as may be pertinent to the study.

2. Liaison officer for MOE, other GOK agencies and USAID/Kenya liaison officer will be identified to the contractor upon arrival of the team in Kenya.

3. The Consultant's team leader, and other members of the team to the extent possible, should brief GOK and USAID officials jointly at least once a week on progress. If, at any time during the study, the Consultant concludes that the project objectives cannot be met, the Consultant should immediately advise USAID and GOK of such conclusion, with reasons, and seek instructions whether to proceed, modify, or terminate the study.

VI. LOGISTIC SUPPORT:

1. All U.S. dollar and Kenya shilling costs for the above services, including logistic support, shall be provided from AID funds available from the Project Design and Support account.

2. The consultant shall be responsible for arranging for all support services required to accomplish the study, such as, but not limited to, office space, secretarial services, supplies and equipment, local transportation etc.

2. AFFORESTATION AND TREE NURSERIES:

1. INTRODUCTION:

The Forestry Department has three programs in Kitui District:

A. Forest Planting Program. The goal is primarily for timber production. It entails planting 5,490 hectares on gazetted hills and 17,859 hectares on ungazetted hills. The length of time this takes depends on how rapidly constraints are removed.

B. Rural Afforestation Extension Scheme. The goal is to plant 450 hectares per year under two Forest Department programs:

1) Small numbers for planting along hedges and gullies.

2) For creating small woodlots on farms that have low potential land.

This will require 7.2 million seedlings per year. In addition, seedlings are to be provided for soil and water conservation activities of the Ministry of Agriculture for planting along cut-off drains and gullies.

C. Protective Forest Plantation Program. This is a new program. For soil and water conservation purposes, forests will be planted in the upper regions of river catchments on land unsuitable for crop cultivation. The goal is soil and water conservation rather than timber production; this calls for different species and different planting and husbandry techniques than where timber is the main objective.

Eight nursery sites are strategically located in the District to service the three programs. Five of the nurseries require further development to bring them up to standard. All eight are critically short on labor for preparing the land and seeding the nurseries. Some are short on water. Perhaps partly because the nurseries are undeveloped, underequipped and understaffed, the cost per seedling is high (Sh.0.95 each.)

II. SCOPE OF SERVICES:

The purpose of this feasibility study is to assist the Forestry Department of the Ministry of Environment and Natural Resources to formulate a detailed plan for the 8 nurseries in Kitui District, so they can provide appropriate kinds of seedlings on a cost-effective basis for both soil and water conservation purposes and for timber production. (While the specific plans will be for the program in Kitui District, the principles will likely have application in other ASAL districts).

The detailed plan called for above should incorporate enough specificity to permit the subsequent development of a project that would warrant AID assistance. In this connection, the contractor should review the Project Paper for the ASAL Development Project (615-0172) under which AID is currently providing assistance to the GOK in the area of afforestation and tree nurseries. In addition, the contractor should review Kenya: Marginal/Semi-Arid Lands Pre-Investment Inventory, "Forestry,", Volume 5, August 1978, which was prepared by the Consortium for International Development under an AID contract (615-0164). Finally, the contractor should consult with officials of the International Center for Research on Agro-Forestry whose headquarters is in Nairobi.

Much of the information required to develop a project in the area of afforestation and tree nurseries will be collected in the context of study 1 described above (Renewable Energy Development Project); in this sense, the two activities are complementary. However, more specific objectives and requirements of this study are as follows:

1. Formulate procedures and organization/management systems suitable for program needs.

2. Develop long-term plans for each nursery, with details regarding species and quantities of seedlings needed each year to attain program goals.

3. Outline an effective seedling distribution system.

4. Outline a nursery research program, aimed at developing improved species or combinations of species for attaining goals in soil and water conservation, timber production, and nutrition.

5. Design a forestry information and monitoring system as a management tool for evaluating progress and assessing costs.

6. Prepare detailed cost estimate for implementing the detailed plan, using Section II. F. above as a model.

7. Carry out an economic analysis for the detailed plan, using Section II.G. above as a model.

8. Carry out an environmental examination of the detailed plan based on AID guidance and requirements.

III. CONSULTANT'S TEAM:

The team described in Section III. above (study 1 - Renewable Energy) includes two forestry experts to carry out this particular study. However, while two studies are involved, the consultants should work as a single integrated team. As stated above, the "Study 1" Project Paper must be ready by early September 1980. Study 2, while important, is subordinate in terms of submission date to study 1.

IV. REPORTS:

The results of the study should be incorporated into a separate written report which will treat comprehensively the information required under Section 2 II above. The draft report shall be submitted to the Ministry of Environment and Natural Resources and to USAID within ten weeks of commencement of the work in Kenya. Within three working days of receipt of the draft, USAID and the Ministry will comment thereon. The final report will be mailed to both parties within two weeks of the Team Leader's departure from Kenya.

V. RESPONSIBILITIES

All responsibilities outlined in Section V. above apply, as appropriate, to this study as well.

VI. LOGISTIC SUPPORT:

All U.S. dollar and Kenya shilling costs for study two shall be provided from AID funds available under the ASAL Development Project (615-0172). The consultant shall be responsible for all support services required to prepare the study, such as, but not limited to, office space, secretarial services, supplies and equipment, local transportation, etc.

Appendix E

INITIAL ENVIRONMENTAL EXAMINATION

Project Location:	Kenya
Project Title:	Renewal Energy Development Project (615-0205)
Funding:	Three year (81-83), $4.5 million
Life of Project:	3 years
IEE Prepared By:	Satish P. Shah, General Engineering Officer, USAID/KENYA
Date:	February 15, 1980
Recommendation:	Negative Determination
Concurrence:	Date: 3/20/82

Glenwood P. Roane
Director, USAID/Kenya

Assistant Administrator's Decision:

APPROVED:_____

DISAPPROVED:_____

DATE:_____

I. Project Description:

The Renewable Energy Development Project provides assistance to the Ministry of Energy (MOE), and to a lesser extent to the Ministry of Environment and National Resources, to permit those bodies to address more effectively questions of energy policy and development and application of renewal and non-conventional energy sources for rural areas of Kenya. Project elements include

(i) Initial planning and surveys;

(ii) Institutional development and training;

(iii) Applied research and demonstration of renewable energy sources such as village household level reforestation and agroforestry; wood and charcoal stoves; charcoal kilns; biomass; solar energy devices for heating and crop drying; water pumping systems; food processing systems and small-scale electricity for clinics, school and other rural services.

(iv) Monitoring and Evaluation.

II. Identification of Impacts:

Elements (i) and (ii) of the project, which include training and technical assistance in developing GOK's capability to formulate energy planning and policy, primarily for rural areas, do not raise environmental issues.

Demonstration and testing of various renewable energy resources under element (iii) of the project will not have significant impact on the physical, socio-economic and cultural environment of rural Kenya. Rather, if demonstration projects such as village/household level reforestation program prove successful, soil erosion will be reduced and further depletion of forest areas for fuelwood will be arrested. The project technical assistance team will include an anthropologist to study socio-economic and cultural impact of technologies being tested. Should any of the specific technologies proposed for testing eventually be selected for major adoption within Kenya, the need for further environmental analysis would then be addressed.

III. Recommendation:

For the above reasons, a negative determination is recommended.

Appendix F

SOURCE/ORIGIN WAIVER FOR COMMODITIES

A source/origin and proprietary procurement waivers are requested for the procurement of five vehicles of Code 935 source and origin.

(a) Cooperating country: Kenya

(b) Project: Renewable Energy Development Project 615-0205

(c) Nature of Funding: Grant

(d) Description of Commodities: Five, 4 wheel drive land rover vehicles

(e) Approximate value: $100,000

(f) Probable Procurement Origin: U.K.

(g) Probable Source: Kenya

Section 636(i) of the Foreign Assistance Act of 1961, as amended, prohibits A.I.D. from purchasing motor vehicles unless such vehicles are manufactured in the United States. Section 636(i) does provide, however, that "...where special circumstances exist, the President is authorized to waive the provision of the act in order to carry out the purpose of this act." Additionally, in accordance with A.I.D. Handbook 1, Supplement B, procurement of motor vehicles of other than U.S. manufacture requires a waiver. The Handbook provides that a waiver may be granted when necessary to carry out the purpose of the FAA and if, inter alia, there is a present or projected lack of adequate service facilities and supply of spare parts for U.S. made vehicles. The authority to (1) determine that special circumstances exist for purpose of Section 636(i) and (2) that there is adequate justification for a waiver under Handbook 1, Supplement B, has been delegated to AA/AFR.

The Government of Kenya has requested A.I.D. assistance to assist in developing appropriate renewable and non-conventional energy resource policies and technologies.

The above project vehicles are required to provide mobility for project technicians who will be required to work in areas where roads are usually rugged, unimproved tracks. While U.S. manufactured right-hand drive vehicles normally would have been satisfactory for this project, it has been determined through experience that the constant shortage of spare parts and non-availability of qualified mechanics to work on U.S. vehicles in rural areas has caused major implementation problems where U.S. vehicles are utilized. The Government of Kenya depends primarily on Land Rover vehicles for its transportation requirements for which service is available throughout the country. It is for this reason that we recommend purchase on Land Rover vehicles on a proprietary basis. Unless project

vehicles are compatible with the country's maintenance system, adequate maintenance and ability to obtain spare parts are virtually impossible.

For reasons stated above, it is recommended that AA/AFR: (1) find that special circumstances exist justifying a waiver of the requirements of Section 636(i) of the FAA, (2) certify that the exclusion of the proposed procurement from Free World Countries and countries included in Code 941 would seriously impede attainment of U.S. foreign policy objectives and objectives of the foreign assistance program, and (3) authorize procurement of Land Rover vehicles on a proprietary basis.