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RENEWABLE ENERGY TECHNOLOGY FOR SOMALIA

prepared by

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Renewable Energy Team
Domestic Technology Institute

March 1980

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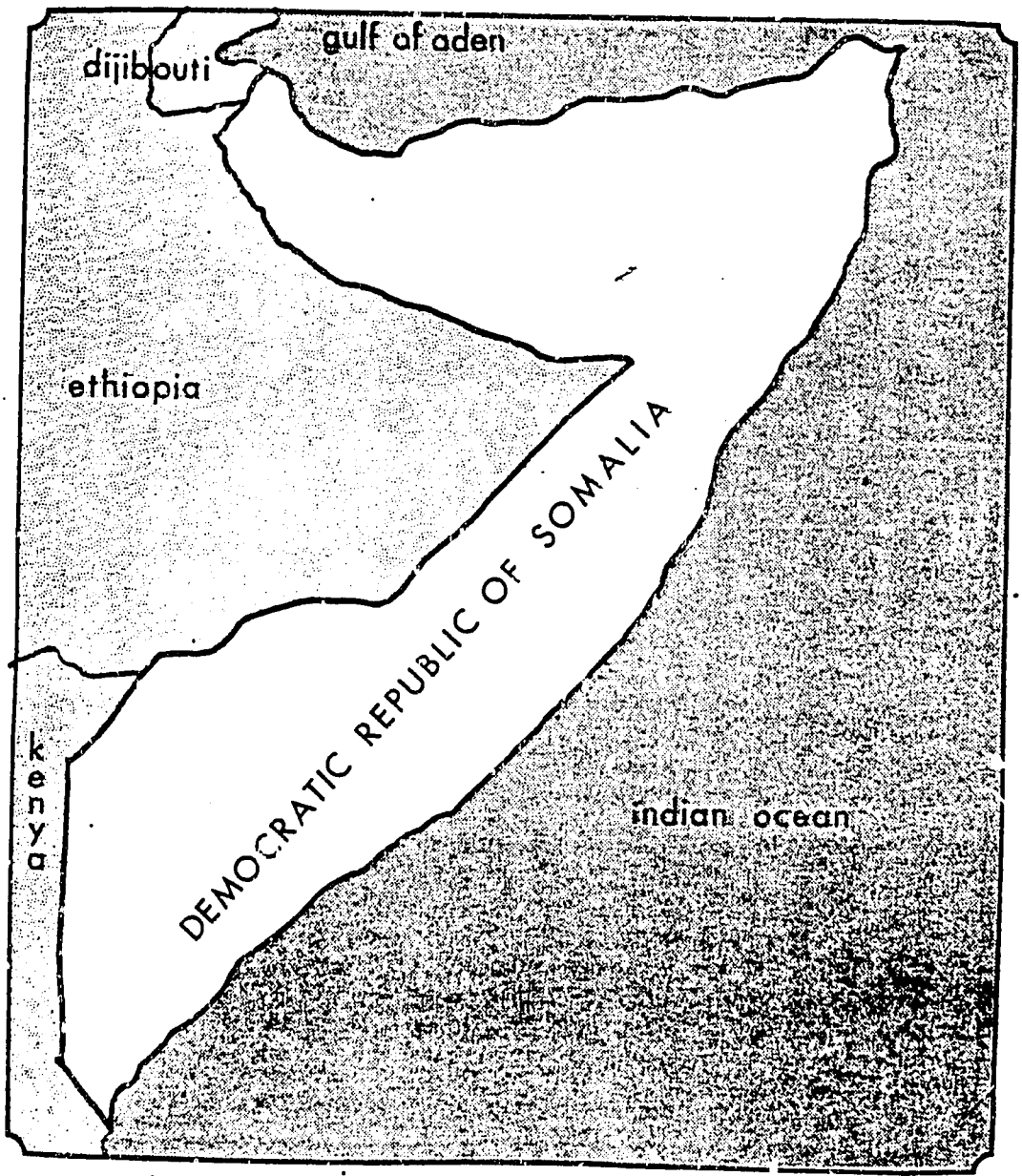

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I. Introduction

This report has been prepared to aid the USAID Mission in Somalia and the Africa Bureau in the selection of renewable energy technologies (RET) to meet the basic needs of the Somali people that are technologically and economically feasible and that can be incorporated as extensions of existing USAID Projects in Somalia. In accordance with the Somalia Mission request, this report does not describe a single project for implementation of RET throughout Somalia, but rather it presents a series of recommendations associated with each of five existing projects. This method of project development can be confusing because many of the technologies and budget estimates are repeated for each project. This report is based on information collected by Malcolm and Lynda Lillywhite during a nine day visit to Somalia in February of 1980.

II. General Demography of Somalia

The Somali Democratic Republic makes up the eastern most part of the continent, known as the Horn of Africa. It covers an area of 246,000 square miles, approximately the size of Texas. The terrain varies from the rich savanna land of the extreme south, to the mountainous area in northern Somalia which is an extension of the Ethiopian highlands. These mountains have the highest rainfall but most of it is lost to the sea. The "Ogo", or plateau, is the most common feature of Somalia and comprises two-thirds of its land area - the central area between the two extremes of north and south. The "Ogo" is mainly poor scrubland but sustains 90% of the livestock which in turn sustain the lives of 65% of Somali's population - the nomads. A fourth area, which is of importance, is the interriverine Bay Region formed by the Juba and Shebelli rivers. The dryland farming of this area produces 80% of the marketed grain in Somalia. The chief crops are durra (sorgham), and maize, with subsidary crops of sesame, beans, squash, bananas, cotton, sugar cane, ground nuts, rice and tobacco.

The population of Somalia is estimated at more than 3.4 million but there is an additional 500,000 to 700,000 Somalis living outside the Republic mostly in the Ogaden. The Muslim faith is the state religion and most Somalis are memebers of the Sunni sect of Islam. Pastoral nomads constitute the vast bulk of the Somali population (70%) with a lifestyle which pervades almost all aspects of Somali life. In contrast to other countries with nomadic minorities, the Somali nomads are not cut off socially or culturally from the majority of urban residents, civil servants and other government employees. At all levels of government and administration, those living a modern lifestyle in urban areas have family members living as nomads and regularly have shares in livestock herds (they often take their vacations to spend time herding camels and living a traditional nomadic life). The nomadic population is responsible for 80% of Somalia's export earnings through stock on the hoof, hides, and skins, etc.

The Somali government is headed by President Siad Barre who came into power in 1969 when he and a number of other military officers staged a coup d'etat. The Somali Revolutionary Socialist Party, modeled after the Soviet system, is the only legal political party.

III. Refugees

Somalia may have the most serious refugee problem in the world. At the time the RET team interviewed the Settlement Development Agency, there were approximately 150,000 refugees and this number was growing at a rate of 2,000 refugees per day. Approximately 25% of the Somali population are considered refugees. These refugees result from two situations: 1) the drought experienced by most of north east Africa, which caused the loss of camel herds, and 2) the Ogaden conflict which has sealed off much of the nomadic territory and resulted in the poisoning of boreholes and the killing of the camel herds on which the nomads depend. These two situations are apparently unrelated, however, Somalis become refugees due to the loss of their animal herds, which is the result of both these situations. Once a nomadic family is without camels, goats or cows they become essentially helpless and the government then attemps to locate these displaced people in communal settlements. The settlement in Kurtenwarre, for example, which is the focus of USAID project #0103 is patterned after the Russian-Ukranian Communal farm-society. It is in these settlements that much of the Mission's interest lies. In interviews with settlement people and nomads, the RET team determined that about sixty or seventy percent of the nomads placed in settlements return to the nomadic life as soon as they can start another herd. This usually happens after a year of settlement when relatives are able to replenish lost camels and goats. (Note: it takes about three camels to support one person and there are approximately 15 million camels in Somalia). Most of the people returning to the nomadic life are men. Women and children choose to stay behind in the settlement where their phase of the work is less burdensome.

The RET team also found that nomads with their herds need and want very few things. The primary need is water. They are not poor by African standards because they have food and firewood, and can realize money by selling one of their animals. Nomads are however, interested in technologies which can grind grain and hull sorghum, (and portable stoves).

In spite of the overwhelming desire for the nomadic life by men and the true self-reliance afforded by this lifestyle, it appears that the drought and the war with Ethiopia have put strict limits on how many people can maintain the nomadic lifestyle. The most delicate aspect of a RET project in Somalia is the use of an implementation process that will support both the refugees who want to or have to live in settlements and still to provide primary support to meet the needs of the lifeblood of the Somli culture - the nomads.

IV. Women and Renewable Energy

Many of the renewable energy technologies that are being recommended for introduction into Somalia pertain to work that is the responsibility of women, i.e., gathering fuel, cooking and procuring water. Therefore, it is imperative that women be included in equal numbers in any development and training programs in the RETs that match these needs.

The woman's position in Somali life is quite active and progressive in comparison to other Muslin countries. This is noticable especially in Mogadishu and in government agencies. However, in the rural areas there still is the traditional separation from men as in other Muslim countries, and especially in rural areas, men take a much more active part in decision making and overall control of daily activities than do the women. On all occasions when interviewing women it was necessary to take the women aside to get answers from them. As long as the men were present, even though asked not to interrupt, they would not let the women express themselves. Male superiority is a strong unstated part of Muslim culture and must be recognized and then dealt with gently.

If these technologies are to take hold and successfully spread, it must be done through the women for it is they whom it will beneift. It is important that they are involved from the outset (developing the designs) to the implementation (training, building, distributing and using these renewable energy technology activities).

V. Basic Needs

A. National Energy Needs. Somalia at present does not have a national or rural energy plan. Inadvertant and unconnected policies developed by various Ministries to deal with their particular concerns has resulted in an increasing dependance on diesel fuel for water supply, irrigation and transportation. Development in the rural area has become intimately tied to diesel powered systems and shortages bring a halt to availability of water.

Somalia imports all of its petroleum based fuels and lubricants. The only refinery in the country is located near Mogadishu, and it is only able to process a fraction of the countries diesel and gasoline needs. This supply is far below the national demand. The fuel supply situation requires government subsidy to maintain basic services for survival such as water in the rural areas and subsequently is causing rapid increases in prices of many commodities and food in the rural areas.

The saving grace of the rural people of Somalia has been the availability of wood and charcoal for cooking. Ninety-five percent of the total energy consumed in the country (domestic and industrial) is derived from wood (and charcoal made from wood). National consumption patterns of Somalia are simply stated: seventy percent charcoal, twenty-five percent wood and five percent butane gas. The long term effect has been to denude regions around settlements, waterholes and towns of vegetative matter giving rise to local desertification and reducing fuel wood and shelter for livestock.

Based on these observations the RET team developed a strategy that would focus on two objectives at the village level. 1) provide economic alternatives to diesel powered water pumping and grain grinding, and 2) reduce the demand for wood fuels by improving combustion and cooking efficiencies. The hope is that these objectives would eventually become part of a Somalia National or Rural Energy Policy.

B. Village Energy Needs.

1. The Definition of Needs. The concept of needs requires brief comment. In abstract terms, the rural poor in Somalia need a great many things: better roads, access to clean water, local food supply, health facilities, more employment opportunities, etc. It would not be possible to meet all of these needs, and not all of these needs

are expressed by the Somalis interviewed by the RET team. In addition, expressed needs taken on their own, may not always be an entirely satisfactory means of determining priorities. Expressed needs often occur within a framework of perceptions of benefits, may alter in different contexts and may also be unrealistic in that they do not take into account the feasibility of solutions. Nevertheless, it is essential that development projects - particularly technologically innovative, self-help projects, such as the one described herein - determine and respond to felt or "real" needs. In order to determine felt needs, both expressed needs (and the context within which they are expressed), and abstract needs (a more objective assessment of what might be required) must be taken into account. The determination of needs should also be made, taking into account what is feasible to provide.

Within this context, rural "needs" have been identified by the Somalia RET team to enable selection of what seemed to be culturally and economically acceptable technologies with a high probability of helping rural Somalis. However, the final assessment and prioritization of needs can only take place in consultation between representatives of village and nomadic tribes, local and provincial governments and the project staff and counterparts. The Somali RET project activities must be designed to utilize this multidiciplinary group in a "survey" process for final identification of needs, technologies and an implementation process, and to allow this interaction to continue throughout the life of the project. At this stage, it is desirable and possible only to establish preliminary needs identification and an appropriate structure and process within which these needs and technologies might be reviewed, to discuss village energy needs in general, and to restrict the final firm recommendation to a few needs and a few technologies.

2. Rapid Rural Needs/Energy Use Survey Method. The RET team followed a systematic method of introduction, interviewing and explaining the purpose of the visit to settlements, nomads, merchants, government personnel and donor project representatives to extract basic facts about village energy use and related needs and to determine which institutions, projects and people are best suited for project implementation. This agenda however, was usually covered in a naturally flow

ing conversation and modified by activities at the time. In most cases, questions were asked of women by Lynda Lillywhite and of men by Malcolm Lillywhite, often using an interpreter. The interview ranged in length from one hour to several hours, over a meal or over the traditional "sugar and tea". Interviews were usually conducted "in situ", that is in the home for women, in the market for merchants, in an office for project and government employees, etc. Approximately 20 women and 25 men were interviewed in central Somalia. Twelve government organizations were interviewed and about 6 merchants.

3. Are Energy Needs a Priority? Energy needs, with the exception of firewood, are not prominent in the RET team's survey of nomads or settlement resident's expressed needs. (Note: water is not perceived to be an energy related need). The reasons for this are primarily that Somalis do not as yet know of the possibilities of alternative energy sources or energy conservation technologies. Somalis and the Somalia local and provincial governments associate development projects with the construction of roads, clinics, schools, village water supplies, grazing control and agricultural extension. Furthermore, the effect of the scarcity of petroleum-based fuels is only now reaching the rural population.

Nevertheless, there is good reason to believe that felt energy needs, other than cooking fuel supply, do exist. This judgment is based on an assessment of current energy-related activities and on the interviews held with Somalis. On this basis, it is concluded that the following are priority energy-related needs:

a) improved water pumping,

b) improved fuel saving facilities for cooking, and

c) a means of increasing rural grain (sorgham) processing.

Other energy-related needs which, at this stage are more tentatively identified, are the needs for improved charcoal production and the cooling of houses.

VI. USAID Projects Recommendations

A. Historical Perspective. AID has been active in Somalia since before independance with the exception of the period from 1971 to 1977 when we were prohibited from working here due to a legislative restriction on AID programs in countries whose ships had called at the port in Hanoi. During the period from 1964 to 1978 AID and predecessor Agencies provided 97.7 million dollars in loans and grants to the Somali Republic of which 92.1 million dollars was during the post independance period.

Early programs included constructing the College of Education and the Agricultural School of Afgoi, constructing the Chismayo Port and doing electrification in Chismayo, doing Agricultural Extension at Baidoa, constructing the Mogadishu Water supply, undertaking Rural Water Programs and numerous other small programs. Enduring edificies include the college at Afgoi, the port, the research and training station at Baidoa and various buildings around town including the Ministry of Public Works Highway Department, the International School, etc.

Near the end of 1977, the present mission was reestablished. Since that time seven major projects have been implemented. The RET team recommendations are based on the understanding that these existing projects would be broadened or expanded to include renewable energy activities and furthermore that these activities would be coordinated and funded through present contracts. (This approach has advantages and disadvantages which will be discussed in the Implementation Recommendations Section).

B. RET Recommendations for Present Projects. Five of the seven projects presently being implemented appear to be suitable for the inclusion of renewable energy activities. These projects together with their RET recommendations are listed below. It should be pointed out early on, that if all five projects do incorporate some of the recommendations made, US AID Somalia will have, in effect, a large national RET activity. The magnitude of the Somalia RET project poses some

problems where implementation is concerned. These problems will be discussed in the implementation section.

The proposed RET's have been selected using three general criteria: 1) suitability of projects to include RET's in the scope of work, 2) basic energy needs of the impact areas in which the project is being implemented, and 3) likeliness of acceptance and follow through by local organizations of RET activities initiated by USAID. The matching of basic needs, RET's and projects is given in table #1.

1. Project #649-0101 - Agriculture Extension Research and Training - $5,050,000 over three years from 1978. This was the first of the new mission projects to begin and is designed to increase agricultural production in the Baidoa Region. A team of five persons from US Department of Agriculture is providing technical assistance to help the extension service work with farmers to allow them to increase production using animal traction, improved horticultural practices, etc. The team is located in Baidoa and will stay for two or three years.

The project facilities, network and staff expenses can be used to help introduce RET concepts and to establish a RET training program. Coupled with project #0104, hand, wind and solar cell water pumping technologies could be provided to the Bay Region. The specific RET's recommended for use in project #0101 are described under other projects, (e.g., #0108). The primary role of the #0101 project in the implementation of RET activities would be to provide facilities and help in establishing extensive and training capabilities. It is difficult at this stage of project development to estimate the cost associated with these services, however, a budget estimate is given for project #0103 which is an extension of this project.

2. Project #649-0103 - Kurtunwaare Settlement Program - $2,100,000 over years from 1979. This project will construct 400 low-cost housing units in the Kurtunwaare Settlement while training local craftsmen to continue the work. The units have

been designed to maximize the use of local materials with USAID providing imported materials, equipment and an eight person techincal team located in Kurtunwaare to manage the program and train the local staff. The technologies recommended for inclusion in this project are listed below.

A) Recommended Technologies

1) Water Pumping

a) Integrated hand and wind water pumping system for community water supply.

b) Animal-powered water pumping for livestock and irrigation water supply.

2) Cooking

a) Earthen wood and charcoal burning stoves

b) Earthen Solar stoves

3) Food Supply

a) Hand and pedal-powered grain grinding and sorgham processing equipment

b) Human and animal powered sesame oil presses.

4) Cooling and Ventillation of Houses

a) Thatch insulation for use with metal roofs if used in the low cost housing project

B) Estimated Budget ($000)

	Yr.1	Yr. 2	Yr. 3	Total
1. Technical Assistance				
a) Wind/Pump Specialist (1 person months)	80	40	20	140
b) Passive Solar Specialist (10 person months)	80	40	20	140
c) Grain processing Specialist (5 person months)	30	30	0	60
d) Earthen (Mud) Stove Specialist (8 person months)	30	30	20	80
e) Sociologist (3 person months)	30	30	30	90
f) Economist (3 person months)	10	10	10	30
SUB TOTAL	260	180	100	540

	Yr.1	Yr. 2	Yr. 3	Total
2. Local Labor	30	30	30	90
3. Commodities				
a) Vehicle (2) (or rental)	30	0	0	30
b) Training Materials	10	10	10	30
c) Mechanical Monitoring and Evaluation Equipment	120	0	0	120
d) Demonstration Hardware	180	40	0	220
3) Energy Saving Devices Construction Materials	10	5	5	20
SUB TOTALS	350	55	15	420
4. Training Costs	10	5	5	20
5. Support Costs (Gasoline, Maintenance)	10	12	18	40
GRAND TOTAL	660	282	168	1,110.00

Note: i) Inflation and Contingencies not accounted for in this budget.

ii) This budget is based on the assumption that all RET's would be implemented in all respective existing USAID projects. Since in practice this will probably not be the case the overall budget would be reduced.

3. Project #649-0104 - Comprehensive Groundwater Development Project - $12,936.00 over 5 years from 1979. This project addresses one of the most critical problems in arid Somalia. It will begin by undertaking extensive groundwater surveys to define the resource base and then move on into drilling production wells. Two hundred or more wells are programmed under this project. AID will finance equipment and supplies and a team of 10 experts, three each at Baidoa, Dusa-Mareb and Galciao and seven in Mogadishu. The RET team recommends the addition of a wind speed and duration survey and analysis to the project so that a wind water pumping system can be installed in an appropriate location. The RET team recommends the clustering of several pumping systems whichcouple high torque low threshhold wind pumping schemes (such as the Fillipini) with hand backup pumps for periods of maintenance or calm (see technical analysis section for more detail). This activity should be coordin-

ated with the similar recommended activity in USAID project #0108 and will require additional technical assistance, hardware, tools and most importantly maintenance and operation training of "water pumpers". This combination of activities is about the only economic alternative to diesel fueled borehole pumps in the near future. Because wind/hand or animal power water pumping systems cannot pump as much water in a given amount of time as a diesel system and also because they depend on sufficient wind conditions, a special implementation process will have to be used. This socially sensitive process must involve local settled residents (if appropriate), nomads and government officials to arrive at precisely how and where these clustered wind systems should be installed, managed and maintained. The RET team interviewed many nomads and "water pumpers" at several boreholes in Somalia and observed that developing a borehole or watering site establishes a complex social and economic system associated with the site. In addition, boreholes make nomads extremely dependant on a single source of water. The RET team does not believe that the present government-managed "water pumpers" procedure is sufficient to manage a cluster wind pumping station. On the other hand, the present policy for wind pumping systems seem to be to install them and let them run until they break. This certainly will not work either. Therefore, it may be necessary to develop a combination of local and nomadic operators with a maintenance team in the long run, particularly in very remote areas. This can only be accomplished satisfactorily if based on discussions with villagers and nomads.

The RET team also recommends testing several shallow well (100m or 300ft.) animal (camel) powered pumps. At present, this is not being used and in most cases is not practital for watering sites that serve large herds and populations. However, some nomads felt this would be a useful technology for remote areas when there is little

or no wind and less than 50 camels and 100 people per day using the site. Also a power take-off unit which wc permit animal, wind or hand pumping should be develc tested and evaluated under this project.

The RET team is also recommending the evaluation of a single 25,000 liter/day (10,000 gallon/day) photovoltaic pumping system. This system is not considered economically justifiable at present but a combination of the increasing cost of water in Somalia and the potential for decrease in cost of photovoltaic systems in the future make it worth looking at now to begin to identify some of the "in field" problems that will be encountered during routine operation by Somalis.

A. Budget

	Yr. 1	Yr. 2	Yr. 3	Total
1. Technical Assistance				
a) Wind/pump Specialist (10 person months)	40	40	20	100
b) Wind System Specialist (10 person months)	40	40	20	100
c) Mechanical Engineer (4 person months)	40	0	0	40
d) Photovoltaic Specialist (8 person months)	40	20	20	80
e) Sociologist (9 person months)	50	30	10	90
f) Economist (3 person months)	10	0	20	30
SUB TOTAL	220	130	90	440
2. Local Labor	40	40	40	120
3. Commodities				
a) Vehicle (2) (or rental)	30	0	0	30
b) Wind Monitering	90	70	20	180
c) Wind System Hardware	110	140	0	250
d) Photovoltaic System	0	150	10	160
4. Training Costs	40	20	20	80
5. Support Costs (gasoline, office supplies etc.)	12	14	20	46
SUB TOTAL	282	394	70	746
GRAND TOTAL	542	564	200	1,306

Note: This budget is based on the assumption that all RET's would be implemented in all respective existing USAID projects. Since in practice this will probably not be the case, the overall budget would be reduced.

4) Project #649-0108 - Central Rangelands Development Project - $14,944,000 over 6 years from 1979. AID is participating with four other donors (IBRD, IFAD, OMD and WFP) to undertake this large ($45,000,000) program in three regions of the country. It will begin with surveys of the range and livestock resources in the area and grazing trails and then move on to installing grazing systems, animal health programs and firewood production to maximize productivity on these dry lands. AID is providing a team of 11 persons, three at Afgoi, four at DusaMareb and four in Mogadishu plus equipment and materials.

The RET team recommends that fuel woodlots and water pumping be added to this project as renewable energy components. The woodlots should be implemented both as privately owned (but subsidized) enterprises and provencial or settlement operated projects. The ultimate goal would be to have the woodlots established by enterprises licensed and trained by the government. Given that fuel wood (or charcoal) production is one of the major income generating activities in rural areas this woodlot concept has a good possibility of being adopted if an acceptable management scheme can be developed and if adequate horticultural, forestry, and management training is provided. Woodlot activities should be coordinated with the extension and training in project #0101 and #0108 if possible. The object of these initial coordinated woodlot projects would be to develop and test a "woodlot management and operation model" and to evaluate the long term effectiveness of this particular approach. The key to success of the woodlot concept in Somalia will ultimately depend upon how the woodlot operation will fit into present fuel wood and charcoal industry. The woodlot management model must be developed around this form while still

achieving environmental benefits and energy conservation. Wood and charcoal burning mud and metal portable stoves developed in project #0103 and #0113 could be included in the later years of this project as an added energy conservation feature.

A woodlot project of this type consists of several stages and would require extensive provencial and national government cooperation over a fifteen year period to establish the basis for a forest management program. USAID Project #0108 should focus on inititating and supporting the beginning phases of this program. These activities should include technical assistance for fuel wood harvest, marketing and consumption surveys, site assessments, tree species selection and horticulture andforestry training; and most important the development of a woodlot management model that will work throughout Somalia. The project should fund and evaluate two test woodlot projects #0101-#0113 and #0108 using Laucaena, Madina Acacia and Eucalyptus tree specimens, and several approaches to operation. During this period USAID could gradually build the long term operational responsibilities of the woodlots into the most appropriate Ministries or other local organizations. Presumably, the work would be initiated through the National Range Agency (project #0108). The test site might be near Baidoa associated with the Bonka Training Center. This facility is equipped to provide room and board, classroom and shop equipment for about 25 persons and is located in an area dominated by small farms. The second site should be located at a similar facility in the central rangelands area.

The RET water pumping systems are however, the priority technologies to be added to this project. The same basic approach outlined in project #0104 should be followed here with perhaps more emphasis on involvement of the nomads and villagers in the site selection, pumping schemes and maintenance training.

A. Budget	Yr. 1	Yr. 2	Yr. 3	Total
1. Technical Assistance				
a) Wind/Pump Specialist	40	20	10	70
b) Arid Forestry Specialist	60	60	20	140
c) Arid Horticulturalist	60	20	10	90
d) Wind System Technical (trainer)	50	0	0	50
e) Sociologist	20	10	10	40
f) Economist	10	0	10	20
SUB TOTAL	240	110	60	410
2. Local Labor	60	60	60	180
3. Commodities				
a) Vehicle (purchase or rent)	30	0	0	30
b) Wind Monitering Equipment	60	20	20	90
c) Water Pumping Parts	120	40	20	180
d) Trees, Fence, Tools, etc.	90	20	20	130
e) Forestry Lab Equipment	30	10	10	50
SUB TOTAL	320	90	70	480
4. Training Costs	60	80	50	190
5. Support Costs Gasoline, office supplies, etc.	16	12	12	40
GRAND TOTAL	696	352	252	1,300

Note: This budget is based on the assumption that all RET's would be implemented in all respective existing USAID projects. Since in practice this will probably not be the case, the overall budget would be reduced.

5. Project #649-0113 - Bay Region Integrated Development - $9,000,000 over 6 years planned to start in 1980. This project which is presently under design will pick up from project #0101 in providing extension services and will go beyond it to provide assistance in rural water, road construction and livestock. The IBRD, IFAD and ADF are co-financing the total of $46,300,000 needed for the project. AID's contribution will be equipment and materials and a five person technical team to reside in Baidoa.

The RET's recommended for inclusion into this project are:

1. Wind Water Pumping System Repair (training)
2. Solar Earthen Ovens
3. Earthen Wood and Charcoal Burning Stoves
4. Sorgham and Maize Processing
5. Sesame Seed Oil Pressing

The water pumping technology should focus on the possibility of training local people to repair and maintain existing wind/hand pumping systems. There are about 100 wind water pumps in this region and the RET team survey showed that less than half of these are working. The wind systems examined had experienced relatively minor problems from lack of maintenance which resulted in fatigued and broken shaft rods or worn out "leathers" in the pump. This could be avoided altogether with proper training, tools and a few spare parts. The project should fund this activity, it will probably yield more benefits in less time than any other alternative in this report.

The Earthen (mud) solar baking and wood cooking units are entirely new technologies and would require considerable social and cultural adjustments in food taste, cooking procedures and perhaps fuel size. However, because of their low cost and fuel wood conservation potential, these technologies should be implemented where there is interest and need. A great deal of support must be given to the initial trainee by the social scientist and the technologist to evaluate acceptability of these units and the process by which they are delivered.

Grain processing includes maize threshing and grinding. Small-scale, relatively low cost commercially available equipment exists to accomplish the first two operations. (However, no small-scale hardware is presently available to dehull sorgham). This equipment is available in the U.S., Japan and EDC countries. Work is presently ongoing in Botswana and Kenya to develop a sorgham dehullar/thrasher and some of this technical expertise and hardware could be tested

in Somalia. This project should attempt to train and establish local entrepreneurs in business that would test, sell and service these developmental and commercially available units.

A. Budget

	Yr. 1	Yr. 2	Yr. 3	Total
1. Technical Assistance				
a) Wind/Pump Specialist	100	20	20	140
b) Solar and Stove Specialist	60	30	0	90
c) Grain Processing Specialist (Third World Hire)	60	0	0	60
d) Sociologist	30	30	30	90
e) Economist/Small Business Management Specialist	20	10	0	30
2. Local Labor	20	20	20	60
3. Commodities				
a) Vehicle (purchase or rent)	30	0	0	30
b) Wind Water Pump Parts	120	40	20	180
c) Curriculum Materials	20	20	40	80
d) Demonstration hardware	110	80	40	230
e) Monitoring Equipment	40	30	0	70
SUB TOTAL	320	170	100	590
4. Training Costs	50	30	30	110
5. Support Costs (gasoline, office supplies, etc).	16	12	12	40
GRAND TOTAL	676	322	212	1,210

Note: This budget is based on the assumption that all RET's would be implemented in all respective existing USAID projects. Since in practice this will probably not be the case, the overall budget would be reduced.

VII. Technical Analysis

A widerange of renewable energy technologies are included in the RET team recommendations in order to meet the diverse needs of nomadic and settled Somalis and to fit into the scope of existing USAID Projects. The sophistication of technologies for water pumping range from the simple hand pump to electric submersible water pumps powered by photvoltaic power systems. For dealing with fuel supply needs, the technologies range from earthen wood burning stoves to improved charcoal production. The need for this technological diversity stems from two observations: 1) the transition phase Somalia is experiencing involving nomads, refugees, settlements and town or cities presents large regional-environmental and social differences and consequently requires different socio-technological solutions, and 2) the fact that the proposed RET activities are interdisciplinary and must fit into the ongoing USAID Projects and the various jurisdictions of Ministries and parastatel organizations requires adaptable solutions. The selection of technologies is complicated by the fact that the RET's proposed such as earthen stoves and wind water pumps cannot directly replace the performance of other non-renewable alternatives like kerosene stoves or diesel powered pumps. In essence, there is little demand in the villages for precisely the RET's that are available to this project and in general the expectations of any new teachnology on the part of the government officials generally exceeds possible performance capbilities. In many cases this has more to do with what government officials want the image of Somalia to be through future development projects than what technologies have a high probability of working in villages and with nomads. However, the new effect of selecting technologies from this multiple set of needs (i.e., nomads, settlements and governments) is that the list is unusually long and some of the technologies are highly sophisiticated. This effectively shifts an even larger burden of projects success to the training activities where proper operation and maintenance is insured and also makes the implementation and project effectiveness evaluation a difficult task. Furthermore, if more than one project adopts the RET recommendations

made herein, it would be inappropriate for the Mission to administer the RET activities and a contractor would have to be used.

The renewable energy technologies have been selected based upon the preliminary need assessment and economic analysis done by the RET team and upon the degree to which the team felt these technologies could be maintained by the rural Somali people using existing institutions. The assumptions leading to these conclusions must be verified and the technologies must be tested early in any RET project adopted.

It is against this background that basic needs, USAID project scopes and technologies were matched. The outcome of this process is shown in figure 1, entitled "Somalia Needs/Technology Matrix". The technologies have been separated into three catagories to distinguish between immediately available, complex and research technologies. The catagories are 1) priority, 2) candidate, and 3) research technologies.

A. Priority Technologies. These RET's were selected because they are technologies which are immediately deliverable to nomads and settlements and do not require research. They are broken into two groups: 1) integrated wind and hand pumping systems for water supplies, and 2) Village Domestic Technologies which supply new or improved sources of thermal energy for cooking, space heating and cooling. This is accomplished by use of solar energy or improved combustion of wood. The Village Domestic Technologies include earthen wood burning stoves, solar earthn ovens and water heaters, thatch insulation and evaporative coolers. (See appendix for diagrams).

1. Selection of Village Domestic Technologies. The following criteria were used to identify the Village Domestic Technologies and tenative designs proposed by the RET team. The RET designs:

   a) must use only renewable energy sources

   b) must meet village expressed or abstract need

   c) must be well understood by the technological community (proven)

   d) must improve thermodynamic efficiencies or time expended by at least a factor of two

e) must be very low cost

f) must be easy to construct and maintain

g) must use indigenous or locally available materials and skills

h) must be environmentally benign or result in environmental enhancement

i) must show the potential of being accepted such that a natural demand for the RET could occur

j) must be presented and designed to permit innovation on behalf of the user

k) must have the potential for marketing of skills and services within the village.

2. "Hands on" Technology. The Village Domestic Technologies proposed in this program are based on sound scientific models. The methods of training used for introducing these technologies to Somalis will enable them to assimilate the technologies by directly involving village people in decisions about and construction of RET units. The "scientific process" is therefore assimilated experientially by the village participants, helping them to discover for themselves how the system functions. This community based technology development process involves Somali participants from its beginning by defining their needs and conceptually developing RET unit designs through a workshop.

This method of turning technology design and development over to the trainees allows the participants to thoroughly understand the technology and the design process within their cultural, economic and social framework and it therefore becomes "their" solution. This process also provides a thorough understanding of how the system works because the participants build, install and operate it. They will therefore be able to carry out the service and repair responsibilities after technical assistance is no longer available. This is the "do-it-yourself" or "self-help" process upon which the village level activities of this project are based.

3. Village Domestic Technologies.

a) Earthen Wood Stoves. Presently, earthen wood stoves are used in Somalia, however, wood consumption of these

stoves is still very high. The "new" more efficient stoves to be used in Somalia must be designed to burn brushwood and small wood logs. The stoves must also be made primarily of mud and stove with designs for indoor and outdoor systems that will hold one or two standard pots. Cement outer coatings may used to make the stove more attractive and for protection. Designs may also be used to decorate the stove and to improve its acceptability. The following criteria for stove design have been identified by the RET team for consideration during early village extension activities:

i. Draft. Fast burning wood sticks do need a draft control while the log fire may burn more efficiently with only a slight draft. Improper use of draft could actually increase wood consumption.

ii. Size and Shape of Combustion Chamber. Slow burning logs require a high combustion chamber with the large main cooking pot located directly above the fire. For faster burning wood sticks a shallow, deep (long) chamber is preferable.

iii. Materials. The sandy soils of Somalia in most cases are not suitable for mud stove construction without the addition of clay, cement or dung. The nomads will not use dung for building or cooking purposes as they consider it dirty and do not like the smell. Areas around some settlements and the interriverine Bay Region have enough clay content in the soil to make mud construction possible.

iv. Construction. The materials necessary to build an earthen stove are: mud, stone of any kind preferably flatfaced (preshaped mud blocks can also be used), dung, sand, some pieces of flat metal which can be made by cutting and flattening empty cans. The tools necessary are: a shovel

or spade, empty tin cans to tunnel into the mud, pick, sledge hammer to break boulders, wheel barrow (not essential), small builder's trowel and a tape measure.

v. Construction Time. The actual construction time for a single mud stove is not long, but curing of the mud takes several weeks. One week should be allowed for the initial base to set and another two to four weeks are necessary for the stove tunnel to dry. For demonstration only, a mud stove can be built and fired in two days. For training purposes, two weeks should be allowed.

b) Solar Earthen Ovens and Water Heaters. These solar heating devices are minature solar greenhouses made of mud and darkened with wood ash to acheive temperatures as high as 140°C (300°F). The solar oven will operate at about 50°C (122°F) higher than the water heater due to its design and due to the large mass of cool water being heated in the latter system. The north sloped mud structures must be covered or glazed with a 2 square meter piece of fiberglass or glass sections to trap the solar energy. This structure can collect approximately 238,000 BUTs/day for heating or baking or the equivalent of about 31 pounds of fire wood (about one head bundle). The primary difficulty with this technology is that it provides only low grade heat and therefore it takes longer to bake bread or heat water than when using a fire. Furthermore, bread baked at 300°F may be of a different texture than that baked over the fire. This solar system can also be built with a wood fire "back up" feature as part of the unit to help overcome some of these factors. The solar oven technology will also undergo many innovative changes in both the baking recipe and unit design once village women get interested in using it. Therefore, the design of these units will not be finalized until late in the RET project.

c) Thatch Insulation. This technology would be tested at Kurtunwaare, project #0103, if tin roofs are used in place of the present thatch insulation. The RET team would not normally consider a non-renewable tin roof advisable, however, due to the negative environmental impact of thatch grass harvest, the great distances it must be hauled by truck and the fact that it must be replaced every 3 to 5 years these thatch roofs may truly not save energy in the long run. At present, only a small number of Somalia rural dwellings are rectangular and incorporate corrugated metal roofs, however the number is increasing. These metal roofs are a status symbol and very easy to install. The heat loss associated with this type of house design with an uninsulated metal roof, makes these houses thermally inefficient, and too hot in the summer. The use of two inches of thatch insulation made by the village women and placed in the ceiling of these metal roof structures could cut the heat gain by 75%. This would improve the comfort of the house in the summer.

A picture of the proposed thatch insulation is shown in the appendix. This insulating material uses short grasses or reeds which women weave into mats and are then laminated with aluminum foil to achieve a thickness of one or two inches. One inch of this insulation material has an R factor of about 4, making it approximately equal to American fiberglass insulation. This technology is recommended because the materials and skills are presently available and the potential for small village insulation businesses exist.

d) Evaporative Cooler. The evaporative cooler utilizes an empty box with all six sides made of charcoal sandwiched between wire or reed retainers and placed on a stand about one meter above the ground and located in the shade. Water is allowed to wick or trickle down onto the charcoal, evaporating as the wind blows, thereby cooling the interior of the box. With a ten MPH wind, 40% relative

humidity and an ambient temperature of 33°C (90°F), temperatures within the evaporatively cooled box can be maintained at 10°C (50°F). This unit could provide a method for preserving produce and clean water. The primary problems of this RET is that it uses precious water, and will not work where humidity is high.

e) Integrated Wind/Hand Water Pumps. The componenents of this technology are available commercially. The project activity utilizing integrated wind/hand pump systems will place hand pumps as a back up or emergency system with each wind system installed at boreholes or on wells. The present plans within Somali government agencies do not plan to use wind pumping systems. The RET project recommendation proposes to provide the respective Ministries with hardware, technical assistance, evaluation services and help in training the water technician in operation and maintenance of wind systems. The RET team was encouraged to make this recommendation by the Minstry of Agriculture and the Water Development Agency. Existing wind pumps depend on a 10 - 15 MPH wind to produce from 4000 - 6000 liters of water per day from a 125 meter borehole. This is only about one-fourth the capacity of a typical diesel pump operating 6 to 8 hours. Therefore, to make wind pumping system performance comparable to diesel pumps, large storage systems and several borehole wind pumps are required in an area of sufficient wind or larger capacity wind pumps must be developed. This multi-borehole scheme should be looked into by the project but at the outset this approach does not look promising. Larger capacity wind pumps will be discussed under Research and Development Technologies, but are not recommended in this project. Present wind technology performance can only meet the water requirements of a small settlement (500 people) with less than 100 cattle or 50 camels. In a settlement of such a size, during periods of calm wind conditions, the emergency water supply could be pumped by hand.

One of the most needed services recommended by the RET team is that of site specific wind velocity assessment. The

project should provide wind/monitoring equipment and training to prospective wind pump borehole locations. This base data will help determine whether a specific type of wind system would be meteorlogically feasible. This work should be carried out on about ten sites each year of the project and coordinated through the University of Somalia.

B. Candidate Technologies. The technologies in this group require further technological development or packaging and also require the development of a comprehensive operation and maintenance training program. These technologies are generally straight forward in their operation but maintenance is somewhat more complex and in some cases the ideas must be marketed to the public. With the exception of portable wood burning stoves, these are also more technically sophisticated and expensive than the priority technologies. The successful implementation of these technologies would probably result in communally, institution or privately owned and maintained systems. Several demonstration units are provided for in the project, however, the exact process for implementation of these pilot RETs is difficult to identify at this stage of development. The technologies included in this group are photovoltaic water pumping, fuel woodlot management and portable wood stoves.

1. Photovoltaic Water Pumping. Photovoltaic or solar cell powered pumping systems are the only RET identified that meets the primary needs of the rural Somalis, water supply, and that can perform comparable to the familar diesel pumping systems now used in Somalia. The technology is extremely sophisticated but routine operation does not present a severe problem. The potential problem arises when the system malfunctions or needs electrical maintenance. For this reason three levels of maintenance/training must be provided: 1) the comprehensive training of two water technicians responsible for daily operation and performance checking, 2) the training of engineering personnel in appropriate Ministry, and 3) the general service training in pilot districts of local gov-

ernment water supply personnel borehole maintenance crews. The project should also monitor and evaluate this pumping system and its maintenance and provide upgrade training when necessary. This type of training and evaluation coverage for the proposed three year period of this activity should be sufficient to insure successful diffusion of photovoltaic pumping system if they can be economically justified in Somalia future water development efforts. However, this clearly is not the case at present, and if photovoltaic pumping was included in project #0104, it would be a long range experiment.

The project would have to provide one complete "daytime" photovoltaic borehole pumping unit at a small to medium sized watering site. The precise system design specifications cannot be given until the sight is selected and the borehole is drilled. However, a four to five kilowatt photovoltaic solar panel unit is envisioned to provide direct power to the submersivle pump. The use of storage batteries is not necessary for this application. A submersible pump capable of 50 to 100 liters/minute (or 15 to 25 gal/min) should be used. With the requirement of four liters/day/person and 50 liter/day/camel or cow this system could serve about 1000 people and 400 head of cattle or 160 camels, and would cost about $110,000 if the system could be purchased at $10/watt. The practicality of such a system providing water in rural Somalia should be evaluated by the project.

2. Fuel Woodlot Management Model. The recommended woodlot component for projects #0103 and #0108 is the most important technology where fuel supply is concerned. Simply stated wood, and charcoal made from wood, is the primary fuel available to the Somalis, both urban and rural, and it is being depleted in manu areas. A RET project cannot propose to conserve fuel wood by implementing Village Domestic Technologies without providing for

replacement of the fuel wood itself. Such a proposal would only reduce the rate of deforestration in most wood gathering areas. Once the model training materials are perfected at a pilot woodlot the same materials could be used throughout Somalia for the development of fuel woodlots.

3. Portable Wood Burning Stoves. These stoves will be developed and marketed through existing businesses, foundries or workshops. The objective would be to market a simple wood burning metal stove to nomads for about fifteen dollars ($15) that could be easily transported. This type of stove is already used in the Sudan and areas of the middle and far east as well as in Lesotho and experiences in these countries could be utilized in the RET stove development work.

C. Research and Development Technologies. The Research and Development Technologies have been identified as technologically feasible but relatively expensive, and in some cases too sophisticated for non-institutional use or technologies which require continual maintenance. In spite of these limitations, there appear to be situations where the use of this type of technology would be warranted and would have significant benefits for rural Somalia. Therefore, the following technologies are recommended for experimental determination of their socio-economic feasibility. These RETs are 1) Advanced Wind Pumping Systems, and 2) Pedal Power Sorgham Dehuller. These RETs were identified based on regional and national needs that would have a direct impact on rural dwellers and that can replace diesel-powered systems. The RET project must also support the development, testing and evaluation of these technologies through existing government and non-government agencies.

1) Advanced Wind Powered Water Pumping Systems. This technology can be borrowed from Kenya or Botswana. The RET project should provide technical assistance to conduct water pumping systems development work and provide all wind pump related training, site maintenance, servicing

and evaluation of the systems tested. The research efforts will focus on adapting high performance wind pumping systems to Somali conditions and for fabrication in Somalia. The initial studies should center around the Fillipini vertical axis system and the ITDG wind pump designs. Other systems could be evaluated t determine their suitability for use in Somalia. The objective of such an effort would be to develop low maintenance, high performance pumping schemes that could produce 8,000 to 10,000 liters/day/borehole and an economic multiborehole scheme with storage that could produce 30,000 liters/day. This would be a large enough unit to service about 400 camels/day.

2. Pedal Powered Sorgham Dehuller and Grinder. This RET responds to an expressed need of Somali women...reducing the labors of preparing sorgham flour. The objective of this activity would be to produce a mobile, human powered system with performance characteristics sufficient for women's grain grinding cooperatives or small business applications. This system could also incorporate a commercially available grinder if necessary. To accomplish dehulling by machine, high speed counter rotating grinding wheels are used to abrasively remove the sorgham hulls. The power requirement for this type of operation is approximately one hourse power and well within the capability of two pair of human legs or approximately 1.2 hp. See appendix. Grinding on the other hand, generally requires more power and less rotational speed. This system would be developed, evaluated and if successful, manufactured and marketed under projects #0103 and #0113.

D. Technological Feasibility. The priority technologies and specific designs recommended are deemed feasible by the RET team based on the limited exposure during their stay in Somalia. However, to insure long term acceptability, design modification must be made by the "users" of the technologies and project staff as the project progresses, and the successful

modifications must be incorporated into the training process.

The candidate and research and development technologies are included in this project so that their feasibility may be determined experimentally. The limiting factors for these more complex technologies however, does not seem to be related directly to the technology but more likely to the ability of the project to provide adequate training of the systems operation and maintenance personnel and of government organizations to carry out maintenance functions.

VIII. Implementation Recommendations.

There are two approaches to implementing RET activities of this nature through existing USAID Projects. A diagram showing the "Single Concept" approach is shown in figure #2. This implementation strategy assumes that a relative small RET effort will be exerted by the Somalia Mission and that the additional activities will be managed by the contractor or USAID project manager. Short term consultants would be brought in under personal service contracts and materials procurred would be done through the Somalia Government. This approach will work as long as the overall RET national level of effort by USAID is small and attached to one project. However, if more than one existing project is extended to test and evaluate RET's this management model may no longer be workable. The primary difficulty is in cross-project accounting and individual technology socio-technical effectiveness evaluation.

The second approach is designed to manage a multi-project RET activity. This approach is called Integrated USAID/Somalia RET Project Support Visit and is shown in figure #3. This implemented strategy establishes a RET Unit which provides all RET related services to each project and is in essence a separately managed project itself. This Unit approach poses some difficulty in using add-on funds from other projects. However, it is probably the only way to insure proper management of a medium or large scale RET effort in Somalia.

Figure 1

SOMALIA NEEDS/TECHNOLOGY MATRIX - RENEWABLE ENERGY TECHNOLOGY PROJECT RECOMMENDATIONS

FELT NEED	TECHNOLOGY	IMPACT AREA	BENEFICIARY	PROJECT ACTIVITY	USAID	IMPLEMENTING AGENCY
Water Supply	• Integrated water pumping systems •hand pumps •animal powered •wind powered	Kurtenwarre Bay Region	Family Settlements • Family Villages	training maintain system repair existing wind systems install hand pumps	0103 0113	Settlement Development Agency Ministry of Agriculture
	• solar cell pumping	Central Rangelands	Family Nomads	replace diesel pumps	0108	National Range Agency Water Development Agency Somalia University Facility Water Development Agency
Fuel Supply	• woodlots • improved charcoal • production	Central Rangelands	Family Settlements Villages	training/forest management/research planting	0108	Ministry of Livestock, Forestry Ministry of Agriculture
Cooking	• mud stoves • solar ovens	Kurtenwarre Bay Region	Women	training/construction	0103	Settlement Development Agency Ministry of Agriculture
Food Supply	• hand and pedal powered grain grinders trashers	Kurtenwarre Bay Region Central Rangelands	Settlements Villages Nomads	training/ marketing	0103 0113	Ministry of Agriculture
	• sesame oil pressing	Bay Region Kurtenwarre	Farmers	training marketing	0113 0103	Ministry of Agriculture Settlement Development Agency
Cooling and ventillating of houses	• thatch insulation	Kurtenwarre	Family Settlements	training in insulation manufacturing	0103	Settlement Development Agency
	• evaporative coolers	Kurtenwarre	Family Settlements	training in insulation manufacturing	0103	Settlement Development Agency

Figure 2

SINGLE CONCEPT PROJECT RENEWABLE ENERGY TECHNOLOGY SUPPORT
Typical Project Organization

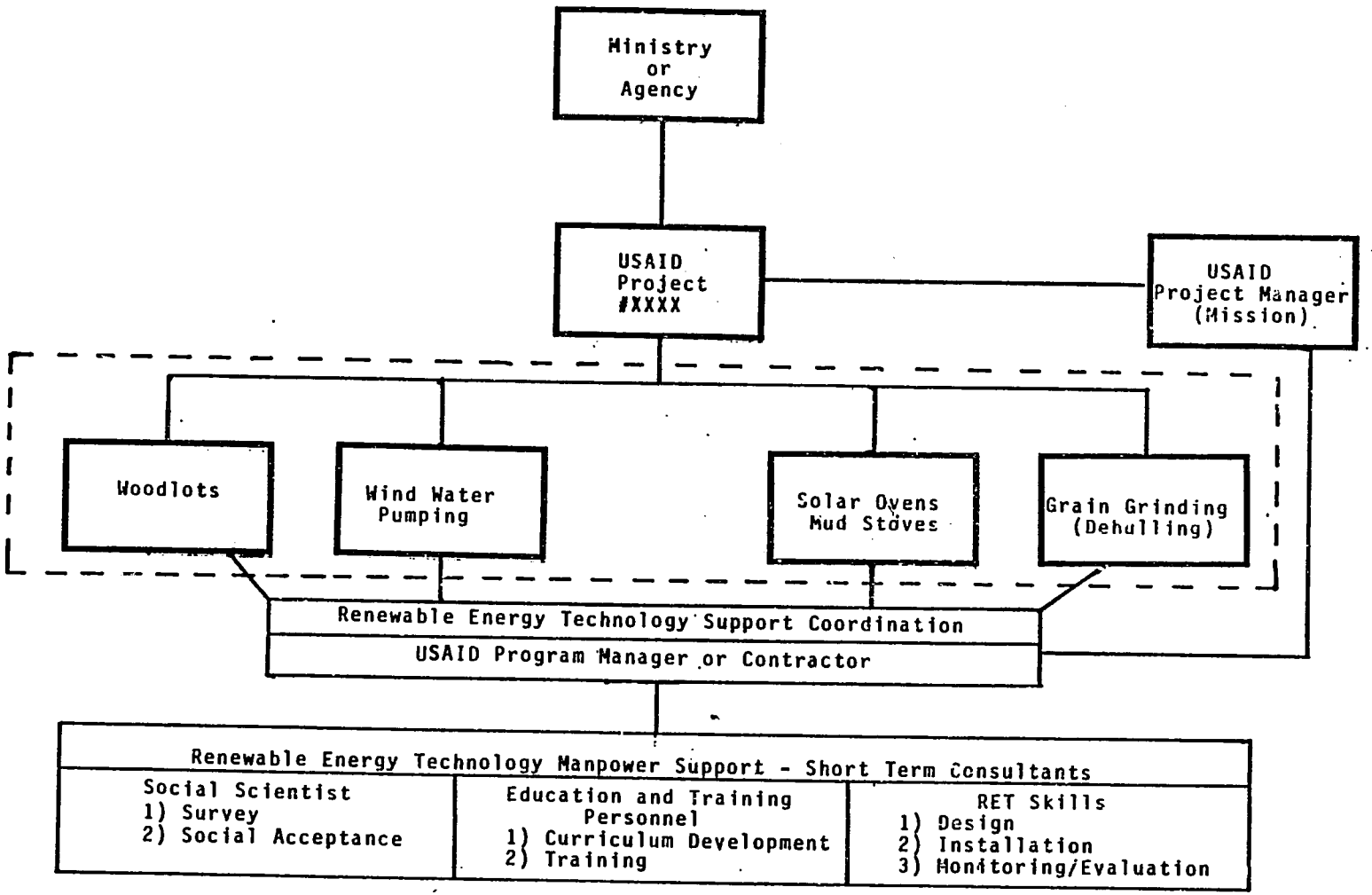
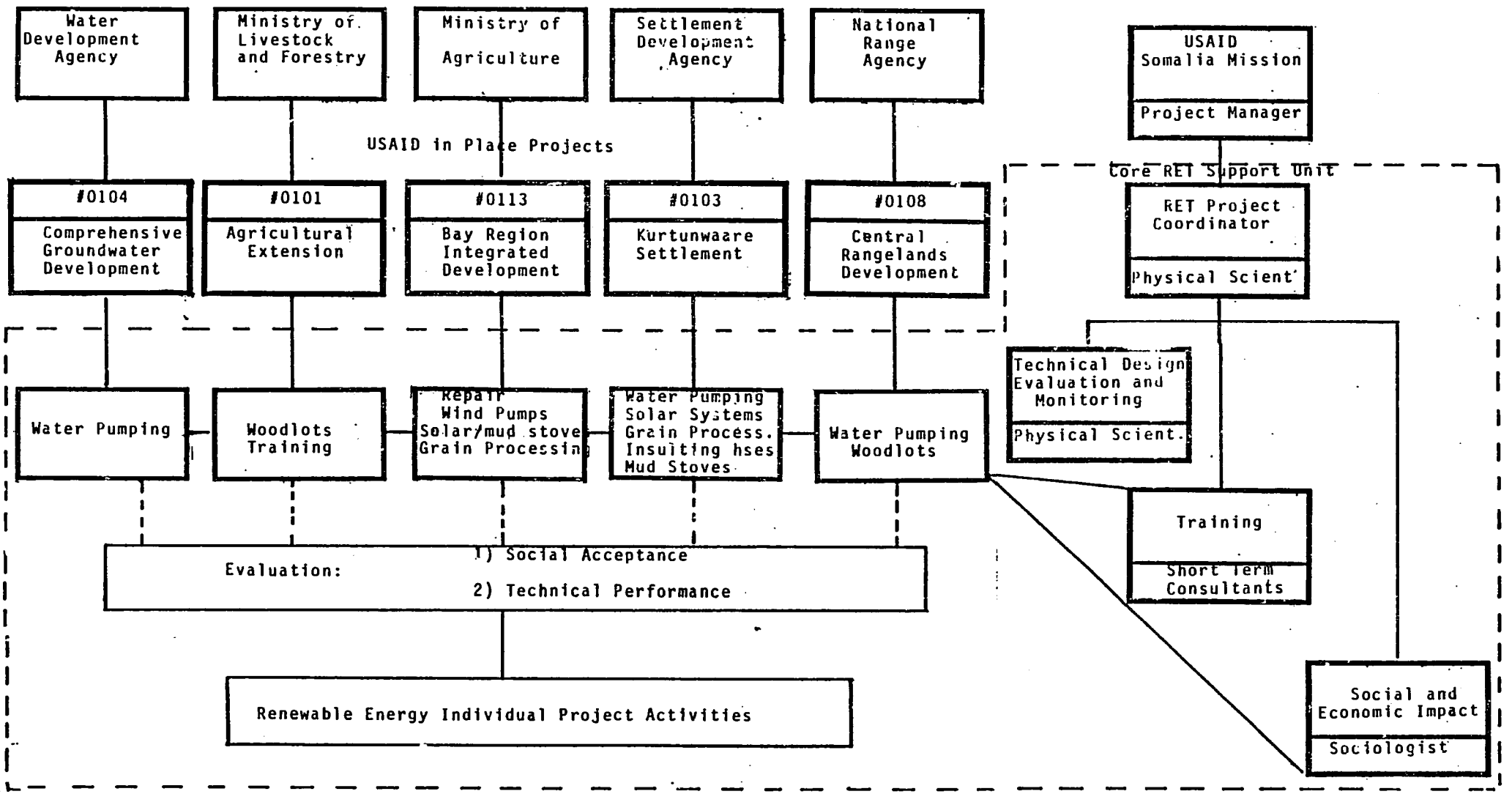
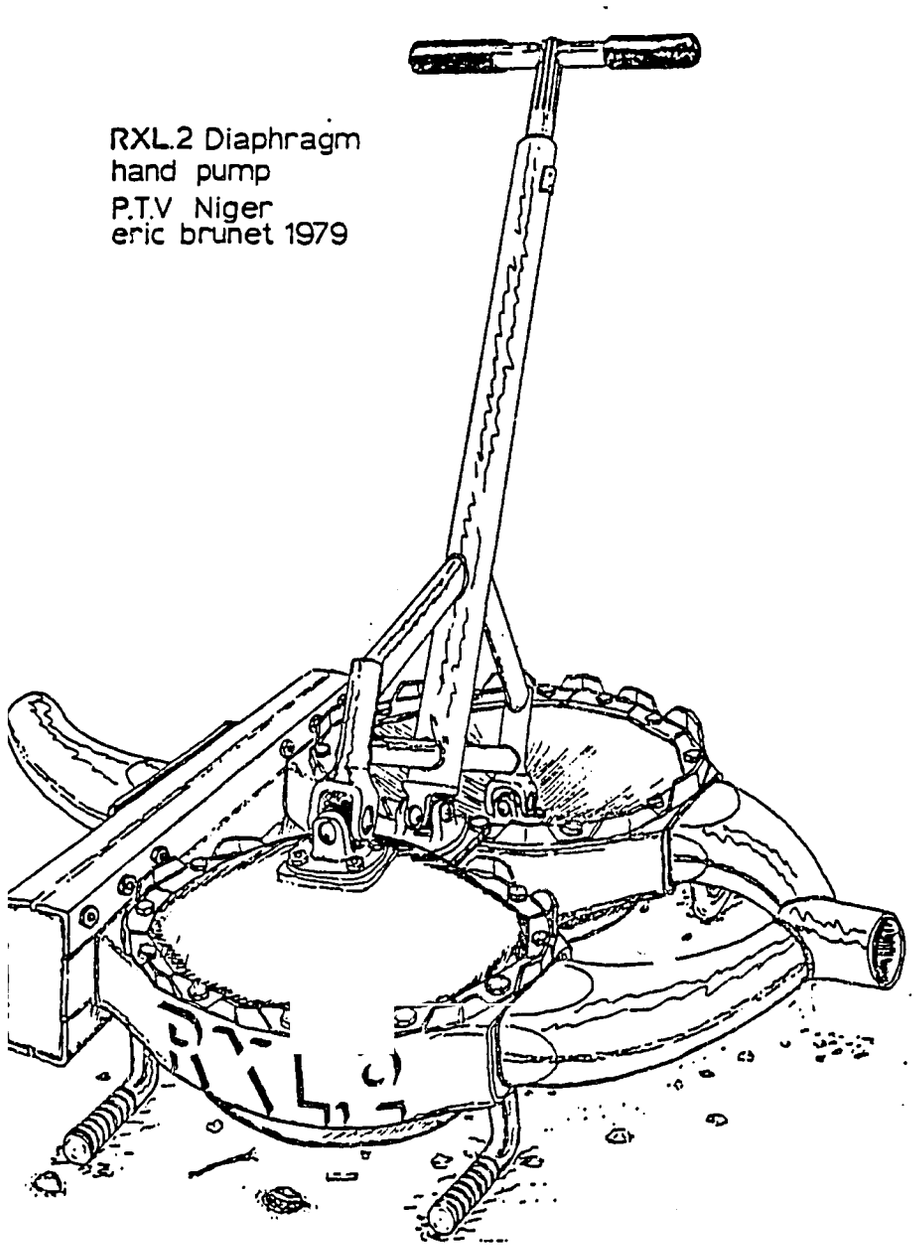


Figure 3

INTEGRATED USAID/SOMALIA RET PROJECT SUPPORT UNIT
Organizational Chart



The following pages show examples of various renewable energy technologies that could be applied in Somalia. These are examples only and it must be emphasized that prior to actual implementation of any of the recommended technologies, a detailed site specific survey must be done to determine the appropriate design for that particular situation.


RXL.2 Diaphragm
hand pump
P.T.V Niger
eric brunet 1979

COMMERCIALLY AVAILABLE HAND OPERATED WATER PUMP

Figure 1

GENERAL

The Robbins & Myers hand pump is a rugged, heavy duty piece of equipment designed for continuous duty on a day in - day out basis. Properly installed and with a minimum amount of maintenance, it will provide many years of trouble free service.

1. Pump Components

The Robbins & Myers hand pump consists of the following assemblies:

Pump Drive - includes gearbox, handles, discharge housing and spout.

Pump Stand - stand and base which is mounted on the concrete pad and supports the pump drive.

Pump Cylinder - includes the pumping elements (rotor & stator) foot valve, and extension tube, and extension shaft.

Well Extensions - sections of drop pipe and pump rod with associated couplings as needed to complete well to desired depth.

2. Well Depth and Water Level

The depth and water level of the well should be checked before installing the pump. The Robbins & Myers hand pump is designed to withstand sand laden water, but longer life and purer water will be obtained by keeping the suction end of the pump cylinder clear of the bottom of the well.

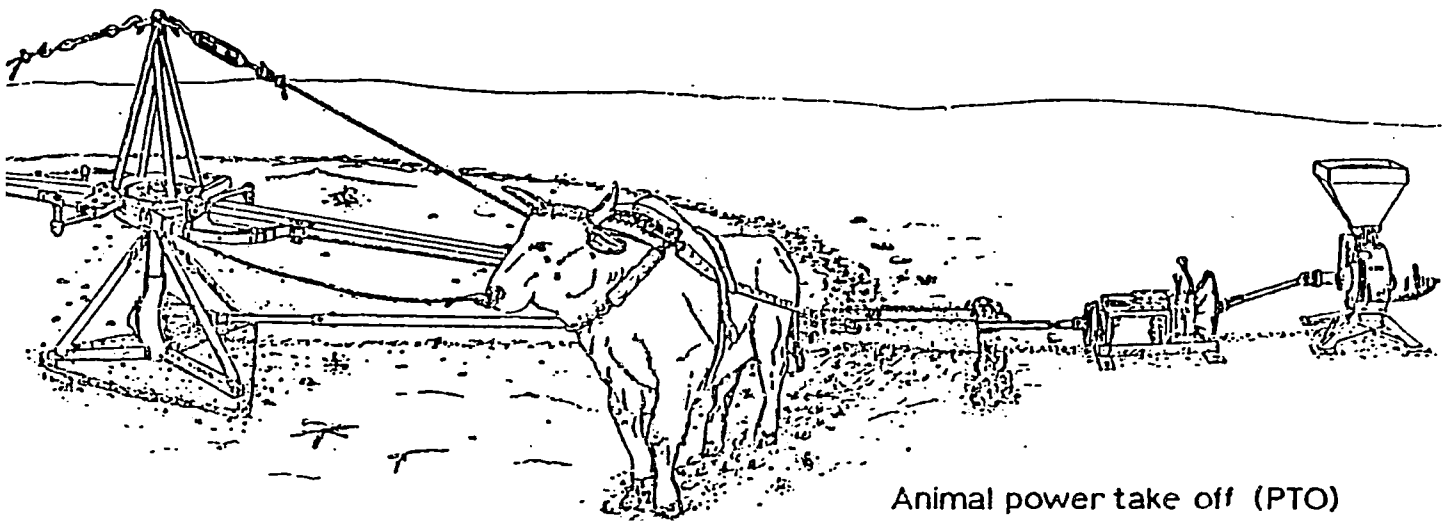
It is important that the well output is sufficient to prevent the pump from running dry. The pumping elements are water lubricated and damage can result if they are allowed to run dry.

3. Well Head Preparation

The Robbins & Myers hand pump is designed to be mounted on a raised concrete base directly over the well casing. The concrete base should be sloped slightly to facilitate drainage of water and the well casing should extend approximately 4 inches (10 cm) above the top of the base to prevent seepage of water into the well.

Mounting bolts (anchor type) should be placed in the concrete base when it is being poured. Correct spacing can be achieved by means of a wooden template or by pre-ordering mounting pads from Robbins & Myers which are dimensionally compatible with the holes in the pump stand base.

ANIMAL POWER TAKE OFF UNIT THAT COULD BE ADAPTED TO PUMP WATER



Animal power take off (PTO)

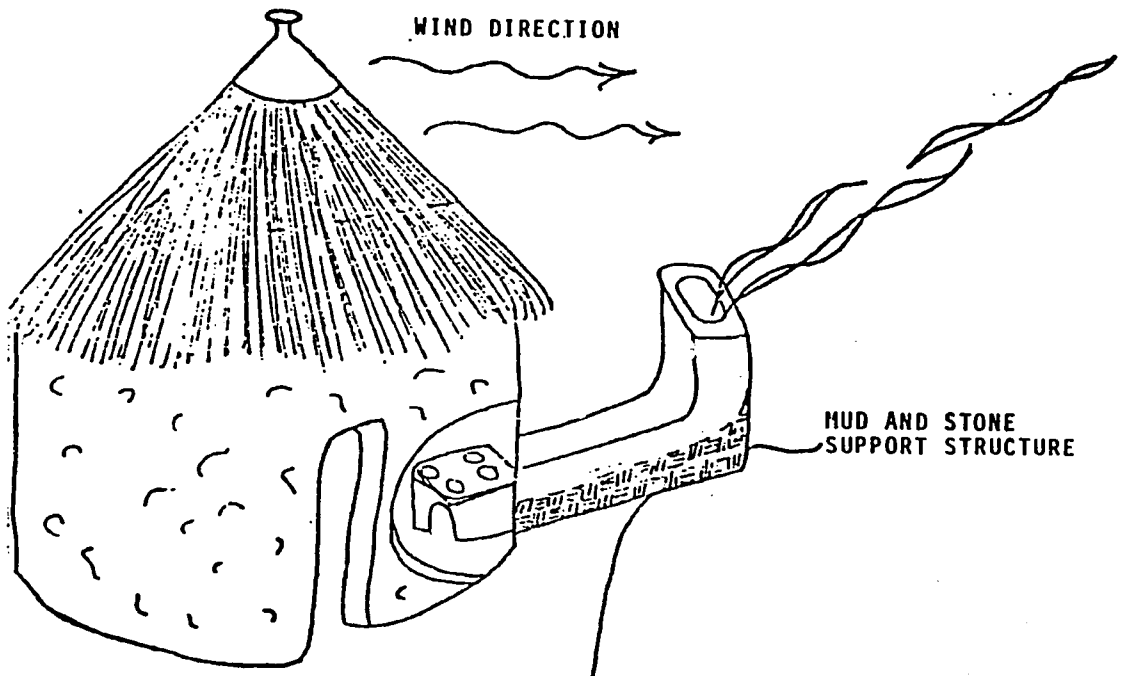
PTV Niger 1979
eric brunet

borehole scheme should be looked into by the project but at the outset this approach does not look promising. Larger capacity wind pumps will be discussed under Research and Development Technologies, but are not recommended in this project. Present wind technology performance can only meet the water requirements of a small settlement (500 people) with less than 100 cattle or 50 camels. In a settlement of such a size, during periods of calm wind conditions, the emergency water supply could be pumped by hand.

One of the most needed services recommended by the RET team is that of site specific wind velocity assessment. The

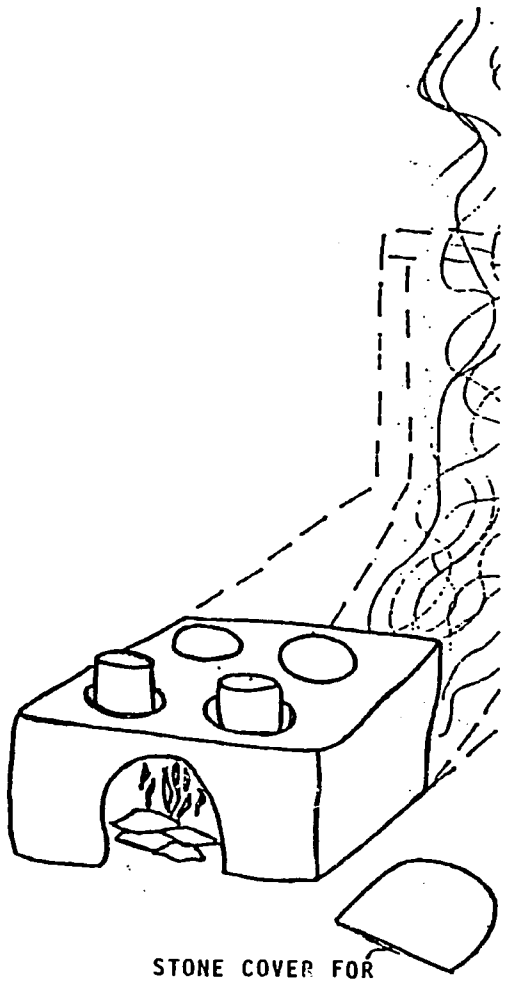
Wood Burning Earthern Stoves

The following five pages show a variety of wood burning earthern stoves to give an idea of the types of sturctures that can be built from resources naturally available to most African villagers. Again, it must be emphasized that the stove to be used in any particular village should be finalized in design in situ, with the women who will be using it.

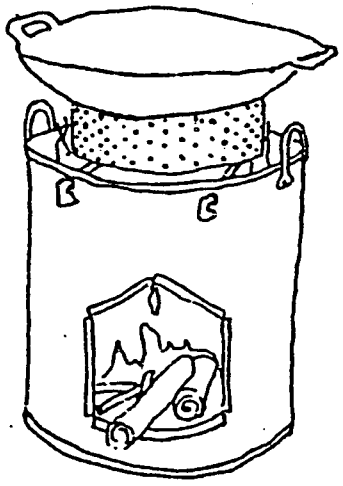


DRAW CHIMNEY ELIMINATES SMOKE FROM
THE HUT AND KEEPS SPARKS AWAY FROM
THE THATCH ROOF

copyright 1979 Solstice Deisgns, Inc.



STONE COVER FOR
STOVE DOOR



The $1.50 Woodburning Stove: this stove is made out of a small oil drum. It can conserve possibly as much as 1/2 the wood that would be used in open fire cooking.

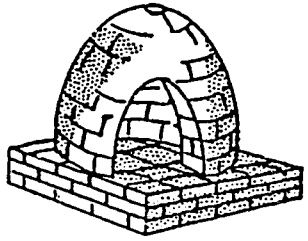


FIGURE 1. THE OUTDOOR OVEN BEFORE BEING PLASTERED.

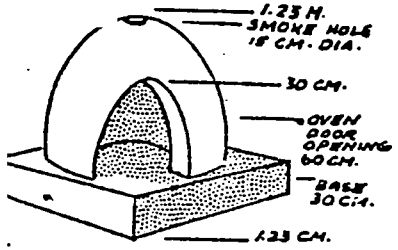


FIGURE 2. THE OUTDOOR OVEN AFTER BEING PLASTERED.

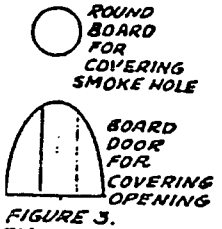
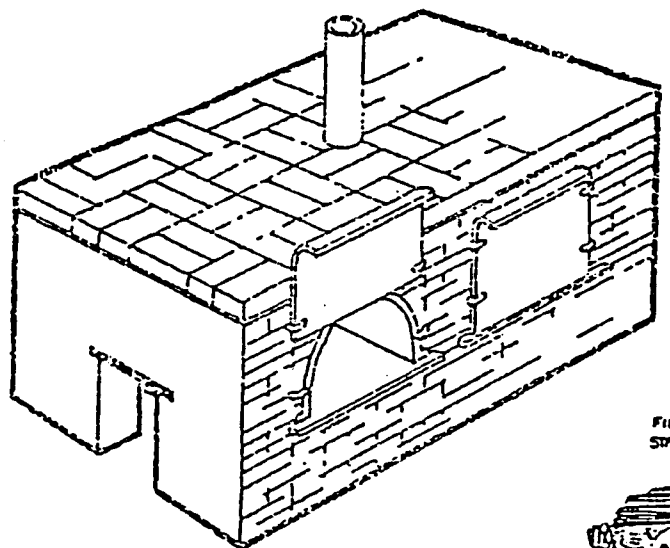
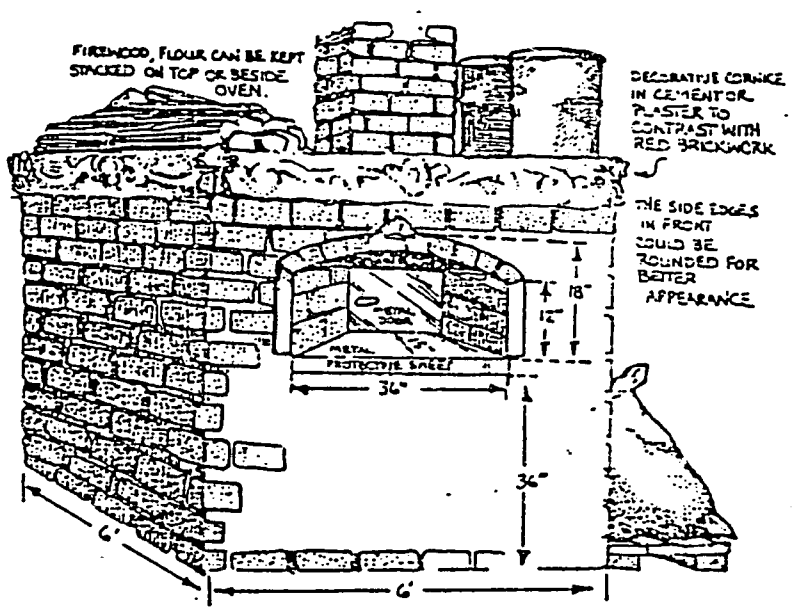


FIGURE 3. TIGHT FITTING WOODEN OR METAL COVERS ARE USED TO COVER DOOR OPENING AND SMOKE HOLE.

TWO EARTHERN BRICK BREAD BAKING OVENS





MAGAN CHOOLA

TOP PLAN

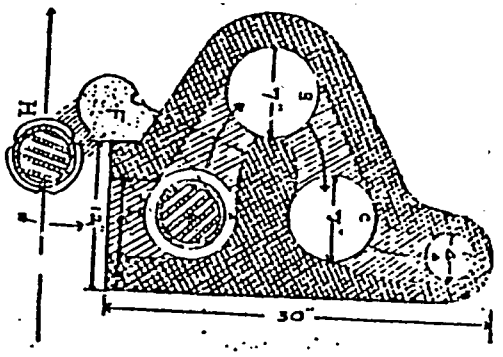
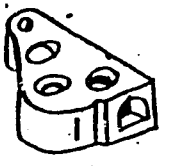


Figure 6

A, B, C pot seats.
D. Chimney base.
E. Grating.
F. Ash removing pit and additional air vent.
G. Damper through choola wall.
H. Charcoal stove on floor level for roti baking.
I. Fuel entrance.



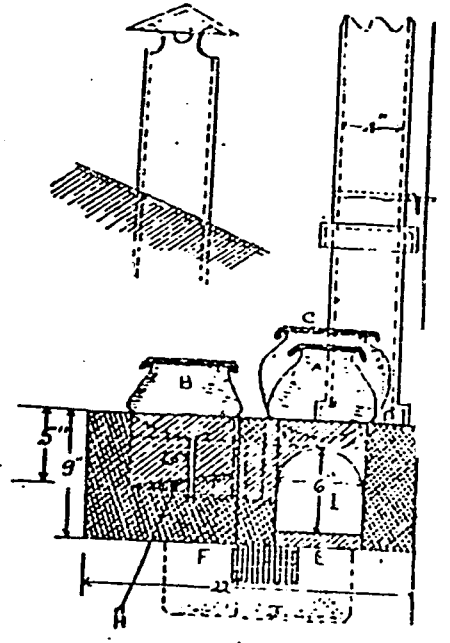
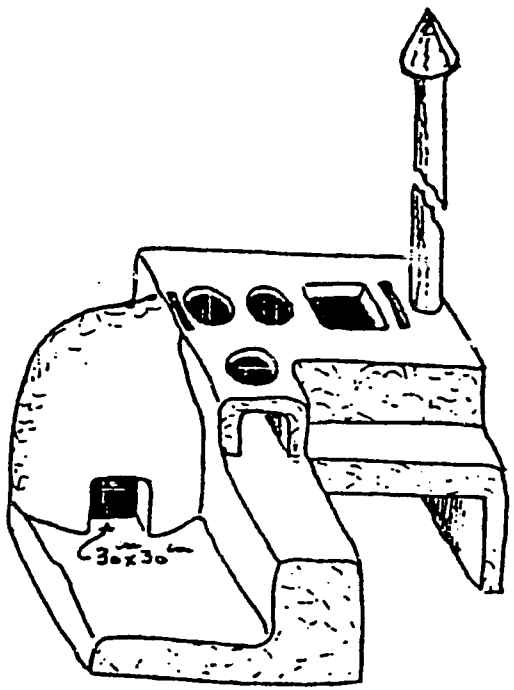
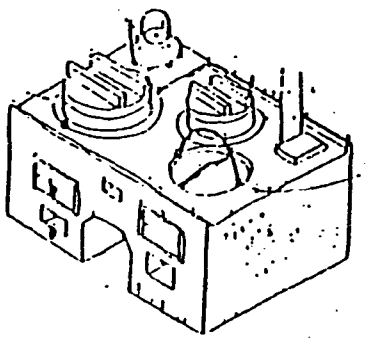


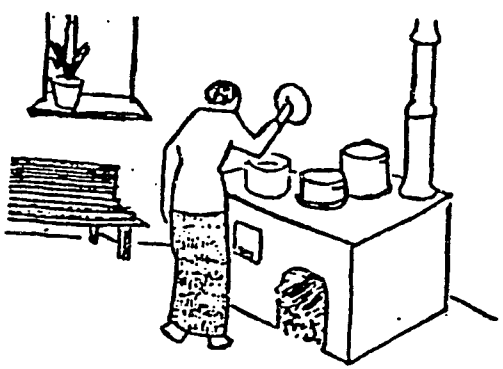
Figure 5

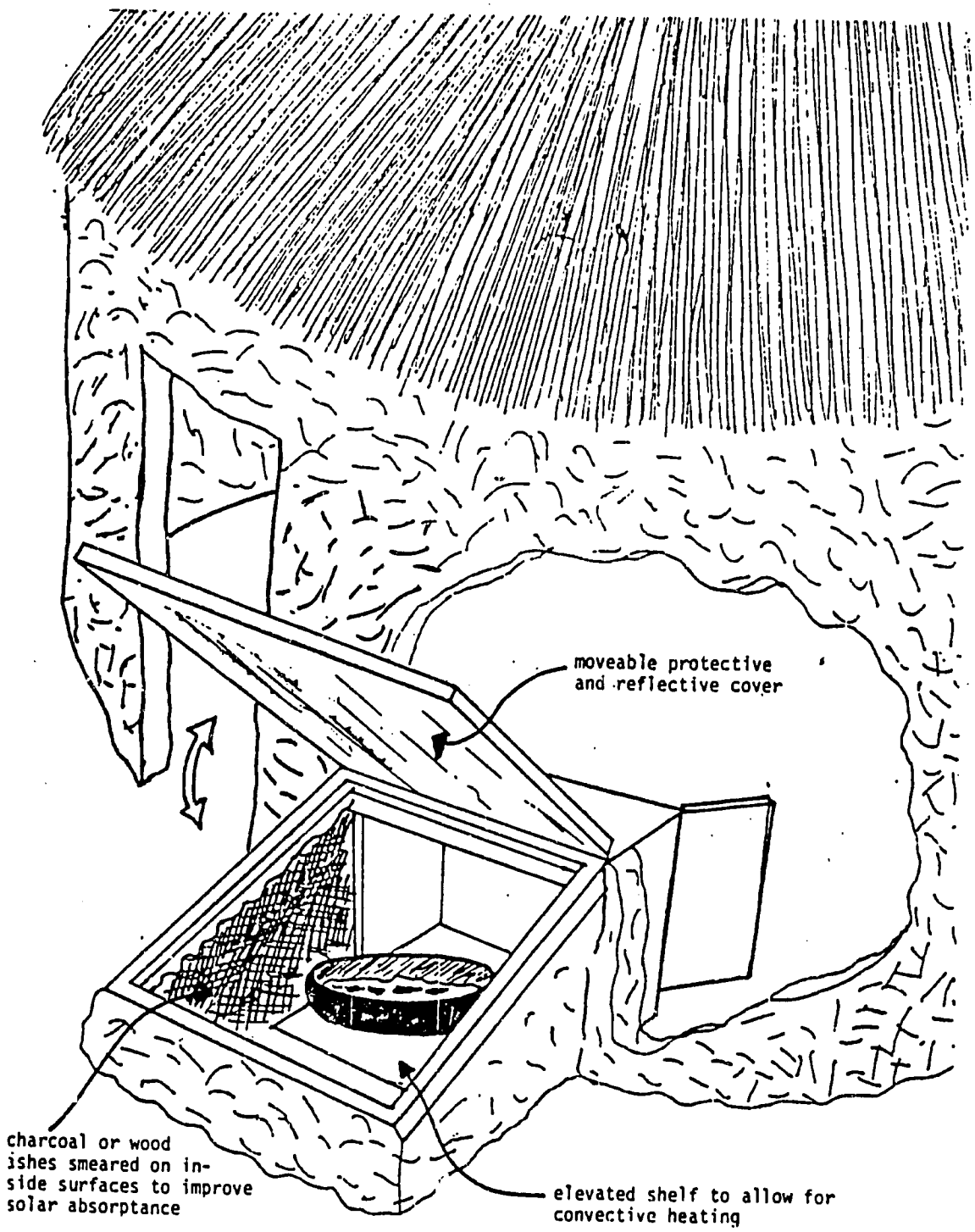
A to G same as explained in Figure No. 6.
H. Baffle Projection to raise flames nearer the vessel.
I. Fuel entrance.
J. Ash pit.
K. Cowl (chimney) above the roof.
L. Roof.
M. Nail in wall to fasten Chimney by wire.





SEVERAL TYPES OF EARTHERN STOVES
MADE IN INDIA





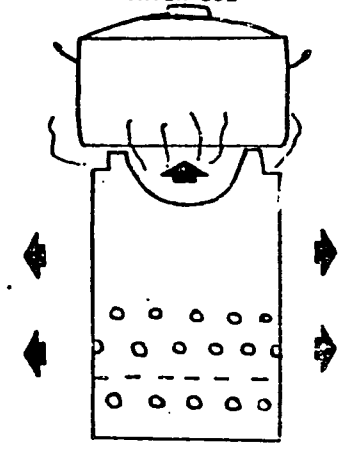
Solar Earthern Oven

Portable Wood Stove

THE PIPE STOVE

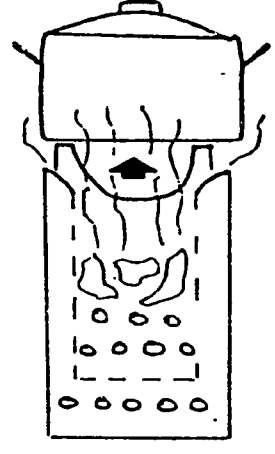
Designed by Willi Suremann for the Ministry of Rural Development in Lesotho

WINTER USE



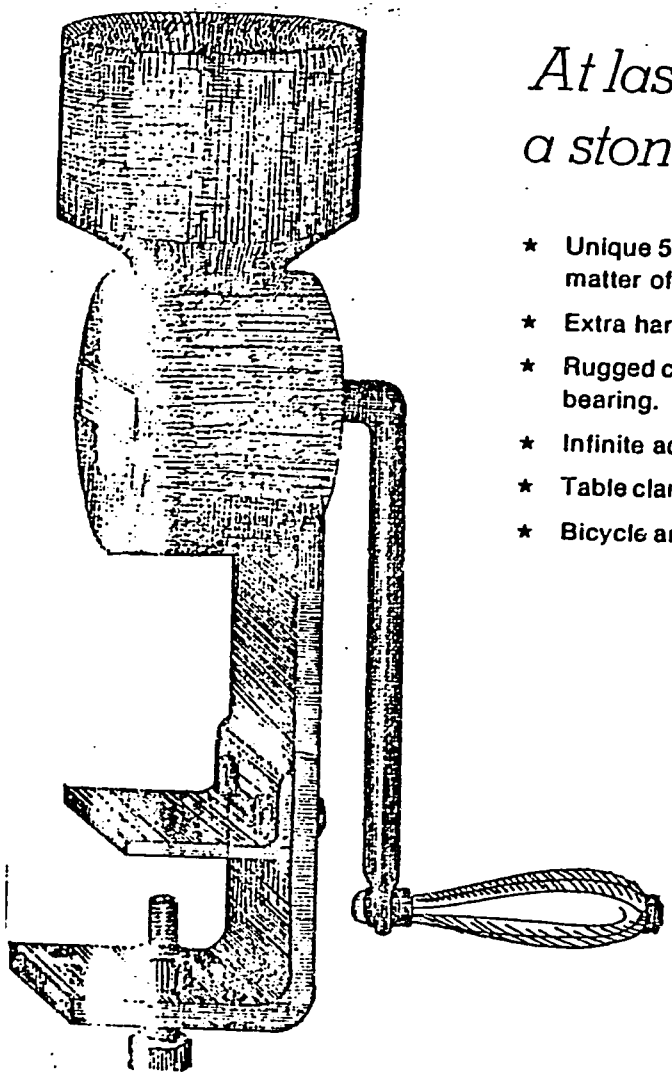
Make a big fire
Heat radiates to all sides
Sit around and cook on it!

SUMMER USE



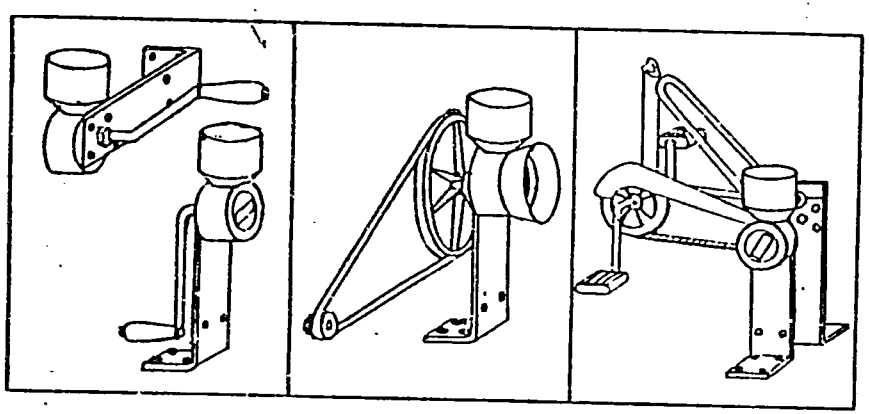
Smear a layer of mud inside
This makes the heat go UP instead of OUT
A small fire burns little fuel
but cooks well!

Appendix E



At last...
a stone hand mill that really works!

- ★ Unique 5 inch diameter stones quickly grind all hard dry grains, peas or beans in a matter of minutes.
- ★ Extra hard heavy duty stones are guaranteed to last for ten years or longer.
- ★ Rugged construction eavy steel stand, steel crank and bronze drive bearing.
- ★ Infinite adjustment g p to coarse cracked first time through.
- ★ Table clamp can be removed for mounting mill permanently to work surface or wall.
- ★ Bicycle and motor conversion kits with ball bearing drive shafts are also available.

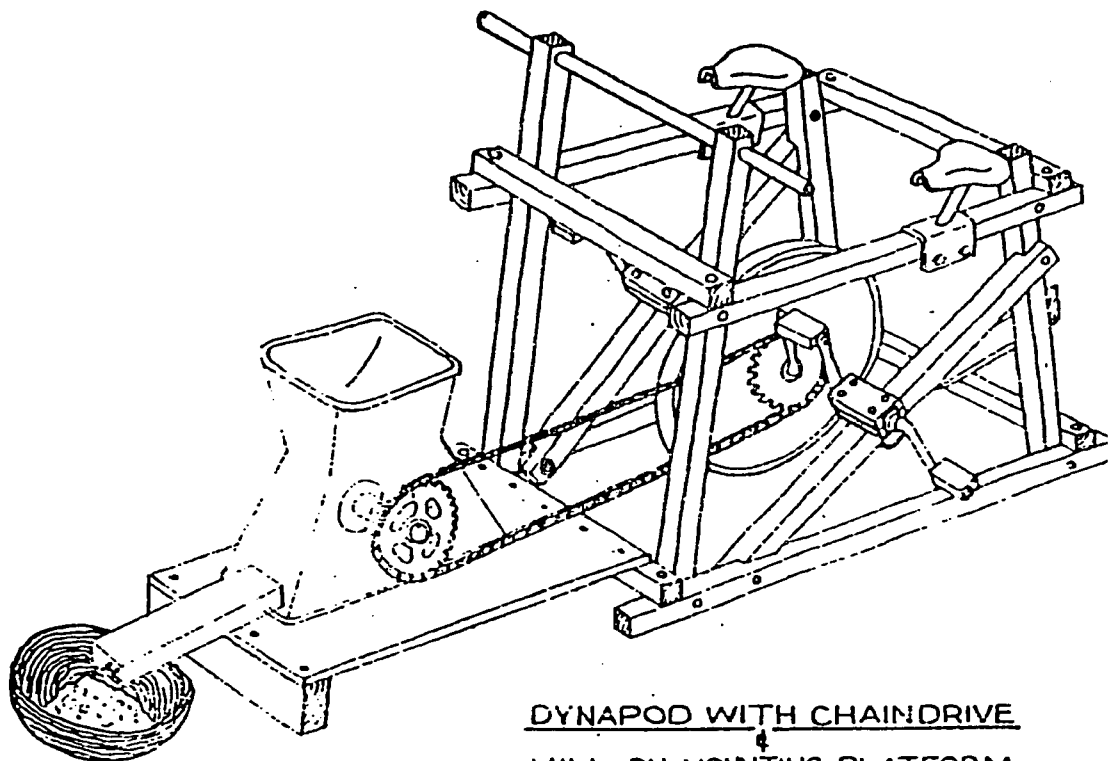


SHOWS GF3C PERMANENT MOUNTING OPTIONS WITH TABLE CLAMP REMOVED. Mill may also be ordered without table clamp. Cost is less.

SHOWS GF3A MOTOR CONVERSION KIT. MOTOR NOT INCLUDED. Use at least 1/3 hp electric motor or 3 hp gasoline. Old washing machine or drive motors work fine.

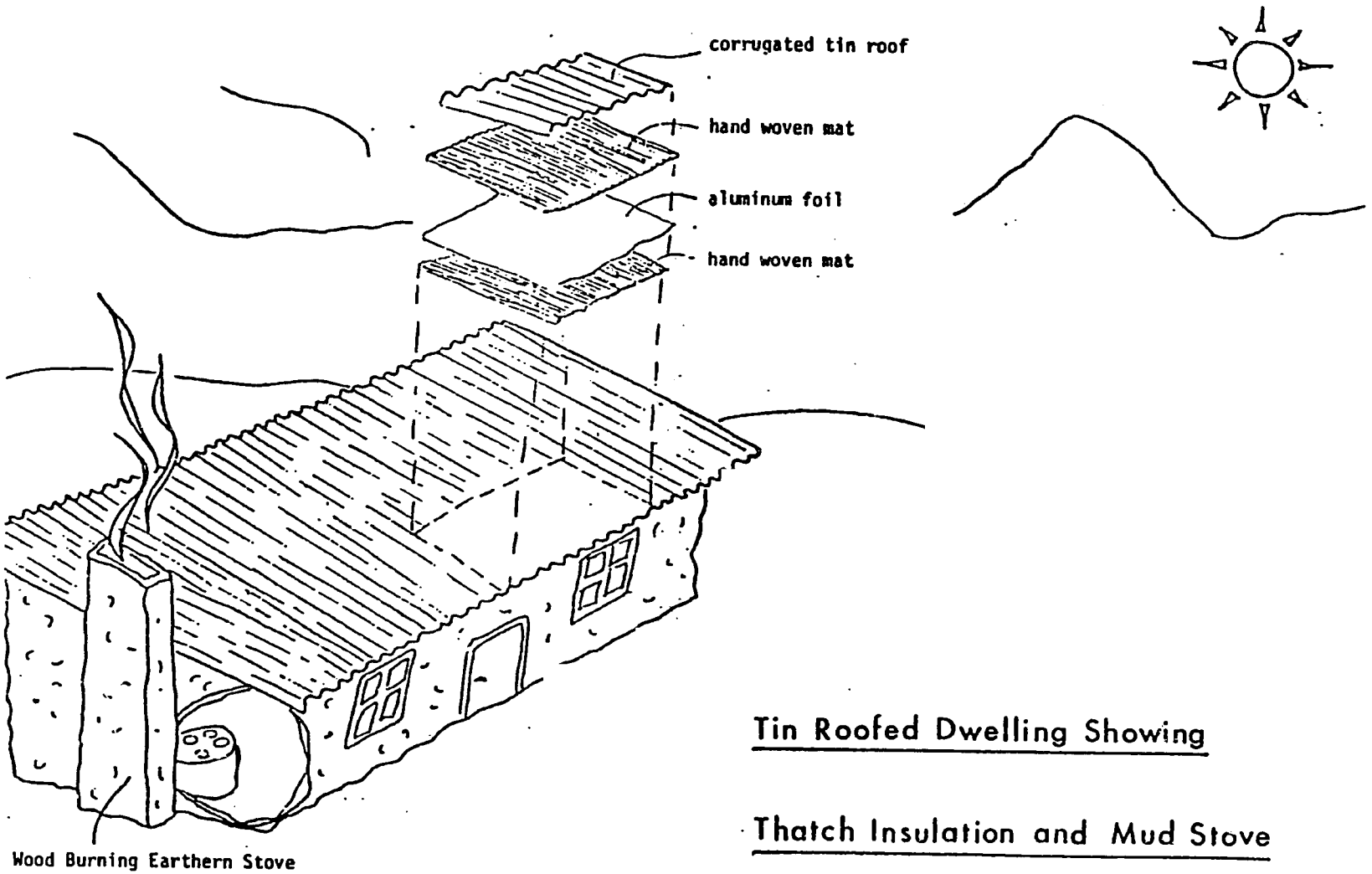
SHOWS GF3B BICYCLE CONVERSION KIT. BICYCLE NOT INCLUDED. Remove rear wheel from conventional bicycle or 3 speed [illegible]

Pedal Powered Sorgham Dehuller



DYNAPOD WITH CHAINDRIVE
MILL ON MOUNTING PLATFORM

(Courtesy of Alex Wier, VITA Publications)



Tin Roofed Dwelling Showing

Thatch Insulation and Mud Stove

THE USE OF PHOTOVOLTAICS TO MEET THE ENERGY NEEDS
OF VILLAGES IN LESS DEVELOPED COUNTRIES

1. Characteristics of a Typical Village in the "Solar Belt" of the Developing Countries of Asia, Africa and Latin America.

Population	500 persons
Number of homes/huts	100
Number of cattle	250
Area cultivated (rain-fed)	100 hectares
Depth of the water well	25 meters
Average number of clear sunshine hours	2500 hrs/year
Solar itensity (average of all sunshine hrs.)	800 watt/m^2/hr
Peak sunshine equivalent	5.5 kwh/day

2. Village Requirements

Drinking water (25 liters per day X 500)	12.5 m^3/day
Drinking water (4 liters/day X 500)	2.2 m^3/day
Water for cattle (40 ltrs /day X 250)	10 m^3/day
Irrigation water (50 m^3/day/hectare for 30 hectares)	1500 m^3/day
Lighting for 100 homes having 3 flourescent lights of 15 w each, in use 5 hours, 3 hrs and 2 hrs respoectively per night	15 kwh/night
Street lighting with 20 flour. tubes of 25 w each for 10 hrs/night	5 kwh/night
Max. battery storage required for 3 nights continuously with 50% discharge from battery	120 kwh

3. Meeting Basic Energy Needs of the Village with Photovoltaic

Activity	Energy Need (kwh/day)	Required Panel Size (peak kwh)
Pumping of water for human consumption and cattle	3	.56
Pumping of irrigation water	200	36.36
Lighting	20	3.64
Refrigeration for medicines(12ft^3)	2.8	.51
Educational TV on videotapes	1.2	.2
Cereal grinders	16	2.91
Small Village industries	29.5	5.37
Total	272.5	49.55

Note: A 10% conversion efficiency is assumed. The roughly 50 peak kilowatt of solar cell panels required per village does not take into account the greatest and most pressing energy need, namely for cooking.

(Part of a presentation made by Dr. I.H. Usmani, Senior Energy Advisor at the United Nations.)