PN-AAQ-267
ISN: [illegible]

DESIGN OF COMMUNITY RENEWABLE ENERGY PROJECTS

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JULY, 1979

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DESIGN OF COMMUNITY RENWABLE ENERGY PROJECTS

Introduction

Assistance to less developed countries (LDCs) in the provision of basic services to the poor and the implementation of programs to improve their economies is a basic and central concern of the Agency for International Development. Energy is an integral part of these concerns, since the development process in its most grandiose terms may be defined in part as simply a trend toward more efficient usage of energy resources.[1] In LDCs this increased efficiency is primarily in terms of augmenting human physical energy with increased increments of non-human sources, thus increasing productivity. Concerns during this stage of progress must include the equitable distribution of these energy sources and the impacts of these sources on the environment and future development of the region. Development throughout history has consisted of finding substitutes for human energy ; yet the majority of people living in rural areas of LDCs still must rely on human power to provide their subsistences.

The other major energy concern for developing countries is the increasing scarcity of traditional non-commercial cooking and heating fuels (e.g. wood, dung, agricultural waste). This has been precipitated by the rapid population growth experienced in the Near East as well as the rest of the developing world. The need to increase fuel supplies to meet this increased demand has led to deforestation near most populated centers and in the Near East and Africa an increasing problem of deserti-

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[1]Energy in this paper includes not only organic and mechanical but also human energy and animal traction.

fication.[1] As traditional fuels become scarce due to the increased demands, regions are forced into the commercial market for conventional fossil fuels and fuelwood/charcoal imported from other areas. In fact, the level of commercialization of energy has become the major rural-urban dichotomy.

The prospect for achieving modern energy technology from conventional resources has been set back by fossil fuel price rises since 1973. These two concomitant forces increased demand for traditional and fossil fuels and the rising prices of these fuels result in a deteriorating economic position for both rural and urban inhabitants of developing countries.

The deteriorating economic position and the development requirements to improve energy utilization places energy projects as important features in any overall country development program. In fact, energy programs must be placed along with rural water schemes as having the highest potential for directly benefiting the living conditions or quality of life of the poor rural population.

Due to the progressive problems associated with fossil fuels there is an increasing interest throughout the world in the utilization of renewable forms of energy[2] to meet the needs of the world's population. In recent years there has been a proliferation of activities in harnessing the four major components of solar energy.

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[1] As a case in point, Morocco is experiencing desertification at a rate of 15,000 hectares a year (DSI report, Renewable Energy and Moroccan Development. 1979)

[2] Renewable energy forms are capable of regeneration (i.e. sources that cannot be exhausted). All sources of renewable energy are related to the energy of the sun. Therefore the literature interchanges the two terms, renewable and solar.

These components are:

--The photosynthesis process by which plants store solar energy in their tissues, thus providing nutriments for animal power and the provision for energy released through fire.

--The power of falling water, made renewable by the sun's evaporation process which raises water from sea level back to mountains and high plateau streams.

--The power of the wind created from the different intensities of solar heat on various portions of the earth's surface, and finally

--Direct energy from the sun's rays which may be converted to heat or directly into electricity.

Recorded international interest in renewable energy dates back to the 1961 United Nations Conference on renewable energy held in Rome. This conference reviewed the state-of-the-art of these resources as well as the technologies which could be used to exploit them. Unfortunately until recently, probably due to the rising cost of fossil fuels, there has been relatively little research and development of these technologies with the exception of solar water heaters, and much of this recent R&D[1] has been devoted to technologies for fossil fuel substitution by the developed nations.

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[1]Renewable energy sources to power the electric grid and the space heating/cooling of homes and buildings. Also research in the transportation field for gasoline substitutes and electric and gasoline efficient engines.

Implementation of energy projects in the third world rural settings requires careful social planning with emphasis placed on the deteriorating supply-demand situation. This may be accomplished by addressing two major issues:

--project designs for more efficient and environmentally acceptable energy sources, and

--project designs for more efficient utilization of traditional and alternative (renewable) energy.

This paper is an attempt to design a methodology for assessing the non-engineering aspects of alternative renewable energy development and energy conservation investment schemes in LDCs, and thereby improve the efficiency of designs. Engineers can design various systems to solve energy related problems, but the appropriateness of the systems is largely a function of the social aspects of implementation and the social parameters of the community. It is attention to these social components which lead to more effective project site selection and design, thus greatly increasing the possibility of end user acceptability and suitability. The social analysis methodology will also assess the community's absorbtive capacity for intervention (e.g. resources for payments, skills for usage, repairs and maintenance of equipment, insitutional capacity for management and cooperation, etc.). Therefore, the social analysis assists not only in selection of the most appropriate technology but also determines the project's feasibility.

At present, there is very little social research pertaining to renewable energy impacts and social pa-

rameters. This phenomena follows the general trend of most engineering breakthroughs. It takes time for data to be collected and evaluations to be made, therefore, there is always a lag in the knowledge concerning the non-engineering components. Unfortunately in renewable energy projects there have been few, if any evaluations The projects are administered and operated under the assumption that renewable energy has got to be good and if the "natives" reject it, they just do not understand. Only recently, due to the increasing number of Project failures, lack of acceptance and institutional capacity are social scientists gradually being invited to become part of energy research and planning teams. From these new efforts and project evaluations, data will be generated to assist in better project planning and implementation.

Due to the dearth of information concerning social issues of energy intervention and a general lack of energy project evaluations, this paper can only provide some general guidelines for an energy development strategy.

The first section reviews current energy needs and resources in the developing countries focusing on problems in the Near East. The Near East energy problems have only recently gained the attention of "donor" countries, possibly because many of these countries are energy exporters. Even these exporters are experiencing energy problems similar to other countries since petroleum is often not the solution for many rural needs. The next section reviews the benefits associated with a well designed energy program, and the last section discusses the general components of an energy project social analysis. A distinction is made between the type of social analysis required and the type of behavioral changes associated with the project technology. This section develops a methodology for energy project planning which carries planners through three basic planning steps concerning the non-engineering components of project design.

I. Current Energy Consumption Patterns, Needs, and Resources

From rudimentary data Dunkerly et al (1978) identified three basic characteristics of energy consumption patterns prevalent in less developed countries. First, per capita consumption of electricity and fossil fuels is very low compared to the developed world. Second, this consumption of so called modern-commercial fuel is found primarily in urban areas. Villages still rely substantially on traditional non-commercial fuel sources consisting of organic waste and wood.[1] Finally, there appears to be little difference in energy consumption levels between the urban and rural poor. This similarity in consumption levels (10 G. Joules per capita) for the poor constituents is due to the proportionately higher rural consumption of low efficiency non-commercial fuels. Inefficiency here is used in the technical sense only. The energy is essential to the villagers, but they have neither the capital nor the technical knowledge to obtain a higher yield of useful energy.

Table 1 presents rural/urban energy needs and energy related tasks with their associated current supply sources. The basic household (domestic) energy needs are for cooking, lighting, and space heating.[2] In addition, rural needs will also include the acquisition of potable water. Highly accessable water supplies for urban areas are provided by municipalities, therefore, releasing

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[1]Organic waste consists of animal dung and agricultural refuse.

[2]Space heating is not an important priority in the Near East except for mountain regions.

Table 1

Origin of Energy Demands and Sources of Supply

Origin of Demand	Source of Supply[1]
I. Urban, Domestic	
Lighting	Electricity[2], kerosene
Cooking[3]	Electricity, gas, charcoal, and petroleum by-products
Space heating	Gas, kerosene, and charcoal
II. Rural, Domestic	
Lighting	Kerosene, wax, and electricity
Cooking[4] and space heating	Dung, charcoal, wood, agricultural refuse, gas, petroleum, (by-products and kerosene)
Acquisition of water	Animal traction, human muscle petroleum, wind power (Egypt)
III. Urban, Industry and Commerce	
Lighting and cooling	Electricity
Manufacturing and Craftsmen/ trades	Electricity
Transportation	Gasoline
IV. Rural, Economic Activity	
Agriculture: Tilling of soil, planting and harvesting of crop	Animal traction, human effort, diesel and gasoline tractors
Water lifting	Human and animal power, petroleum driven pumps, wind mills (Egypt)
Food processing Grinding and thrashing	Human and animal power, petroleum driven machines, water driven engine (very rare in Near East)
Drying of crops	Direct rays of the sun (without protection), heat from burning dung and agricultural refuse
Drying of meat	Smoking (charcoal and agricultural refuse) and salt curing
Trades, craftsmen, and handicraft Small Manufacturing	Human energy expenditure, electricity (if available for lighting and machine)
V. Public Social Services	
Schools and health clinics Community Buildings	Electricity for lighting and refrigeration (in rural areas diesel fuel may not be available)

[1]Sources are listed in descending order of usage and demand. In a few incidences adjacent sources have similar usage rates.

[2]Electricity is produced mainly by petroleum, but in Egypt and Afghanistan also partially by hydro-power.

[3]A petroleum by-product resembling Tar is used as a fuel for cooking in the cities of Tunisia

[4]In Egypt dung is the principle cooking fuel in rural areas. In other areas of the Near East dung is not used quite as extensively.

urban population of this concern.

Domestic cooking accounts for most of the energy used in LDCs' rural areas. Estimates from a workshop on Energy and the Food Systems of Developing Countries[1] concluded that from 60 to 90% of the energy in rural areas is connected with the food system of which cooking accounts for 60%. For example, 88% of the total wood consumed in the Near East is for cooking; other domestic fuel sources are crop residue, vegetation and primarily in Egypt, animal dung. Although most of the rural fuel is non-commercial organic materials, there is a general trend toward an increased demand for fossil fuels owing to the increasing scarcity of traditional fuels and price subsidies placed on these petroleum products. Another trend toward increased usage of cleaner burning fossil fuels is associated with rising family incomes.

At the community level and in the economic sector the food production chain for rural areas and trades and industrial manufacturing for urban regions create the major demands for energy. Secondary demands occur from community service delivery systems such as health clinics, schools, and urban/rural water and waste disposal systems.

The primary rural fuel sources to meet these demands are organic waste (agricultural refuse and dung), wood/charcoal, direct solar heat for food drying and to a small extent kerosene. While in urban regions fuel supplies are commercialized and consist primarily of electricity, charcoal, and petroleum products (butagas and kerosene).

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[1]Cornell University, College of Agriculture Conference, 1977.

Most of the village tasks are done with human energy or animal power. These tasks with the exceptions of pumping and/or carrying of potable water and gathering of organic matter for fuel are related to the production, processing and transportation of food. These activities of soil preparation, planting, irrigation, harvesting, threshing, grinding, and crop handling are not only a physical burden due to the lack of supportive energy resources but this inefficiency also inhibits developement in five basic ways (Howe, 1979):

--There is often an important labor shortage at critical times in the crop cycle.

--Crops and other commercial valued goods are transported by foot or animal power which puts a low ceiling on the extent of trade.[1]

--Most villages are condemned to darkness in the evening which limits the hours available for educational or commercially productive activities. Also from experience in the Phillipines, the lack of lighting is a contributing factor to a high birth rate.[2]

--The complete reliance on wood, dung, and crop residue for cooking and heating results in the land being progressively devegetated, drained of nutrients and eroded; and finally,

--The villagers are confined to water hauled from streams or often open wells which are inadequate for irrigation and may perpetuate diseases.

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[1]This does appear to be a major problem in the Near East given the close proximity of cities to most agricultural lands.

[2]An AID Financed Evaluation of the MISAMIS Rural Electric Service Cooperative in the Philipines showed a sharp decline in the crude birth rate in the wake of electrification.

Hence, the greater the reliance on traditional energy, the more likely it is that village residents have a low income, low physical quality of life and little potential for development.

Given these energy constraints on development and improved quality of life for rural areas to what extent can these areas be served by conventional "modern" sources of energy?

Electricity Grids are the most visual symbol of modern energy systems. According to the World Bank (1975) only 15% of the Near East population[1] is presently being served by these grids with only a small increase expected in the 1980s. The inhibiting factors for centralized electricity are the large investments associated with extending the grid to dispersed areas and for generating a capacity which involves considerable risk due to demand forecasting errors. Even if electricity were available it may only be a marginal form of energy due to its questionable appropriateness for the dominant task of cooking, pumping water, processing and harvesting crops.

Petroleum Products accounts for well over 90% of the total commercial energy supply (direct and indirect thru electricity) in the Near East Bureau countries (Table 2). Only Afghanistan and Egypt produce large quantities of electricity from hydro-power. Present energy trends have already started LDCs down the petroleum based energy path. Kerosene is being used for lighting, diesel engines for electricity generation, pumping and grinding. This reliance on petroleum is detrimental to balance of payments for most third world countries.[2] There is a need

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[1]Data included countries of Egypt, Algeria, Iran, Morocco, Saudi Arabia, Tunisia, and Turkey. (Rural Electrification, 1975)

[2]Morocco, Jordan and Yemen in the Near East are energy importers. Although Egypt exports petroleum they are presently importing methane gas for domestic consumption.

Table 2

Energy Consumption Patterns and Electricity Production
Of Selected Near East Countries and North America*

	Per Capita Consumption patterns (kilogram of coal equivalent)		Exports of Energy	Electricity Production 1976 (million of Kw)	
	1973	1976		Petroleum	Hydro-power
Afghanistan	43	41	Yes	158	503
Egypt	294	473	Yes	3,200	7,000
Israel	2,952	2,541	No	9,968	—
Jordan	349	527	No	388	—
Morocco	244	273	No	2,101	978
Saudi Arabia	1,272	1,901	Yes	2,250	—
Syria	435	744	Yes	1,500	—
Tunisia	396	456	Yes	1,286	53
Yemen	26	41	No	45	—
Yemen, Democratic Peoples Republic	485	324	No	110	—
U.S.A.	11,738	11,554	No	1,752,807	283,680
Canada	9,632	9,950	Yes	74,671	189,364

*Source - United Nations Yearbook, 1978

to diversify energy sources dependency. Even with the high petroleum subsidies found throughout the Near East, fuel transportation and cost of these fossil fuels are a major constraint on the meager budgets of the poor.

Nuclear Power is usually not size appropriate. The smallest generators available are 600 megawatts and for economic reasons industry favors increasing the size. Even this smaller model is too large to be reliable for power grids in most of the developing countries. In addition, the economic, environmental and security problems associated with nuclear energy do not make it a promising source of energy.

Given these present and potential problems with the continued reliance and expansion of modern conventional energy, the Near East countries with help from 'donor" agencies need to devote their energy planning efforts toward the development of renewable energy resources and technologies. These technologies have greater feasibility since they are available in size appropriate units that are easily increased as demand dictates. This piecemeal approach to energy infrastructure decreases the risk of demand forecasting and allows for decentralized planning. Implementation of these new energy systems is a necessity if the rural and urban poor are to be able to improve their living standard. These renewable energy sources will not only be substitutes for present fuel sources, but will also aid in increasing the the community productivity thru their substitution for the less efficient and sometimes inappropriate energy sources of human labor and animal traction.[1]

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[1]This is not to imply that draft animals should not be a component in an energy plan. Draft animals are often necessary substitutes of human labor and provide an intermediate fuel source (dung) for direct burning or methane gas production (biogas digestor). There are tasks in which draft animals are not efficient (e.g. threshing, pumping water, and to some extent transportation).

II. The Accrued Benefits from Well Designed Projects

At the most inclusive abstract level the basic benefit from renewable energy programs is improvement in quality of life. In rural areas, these will have the effect of slowing down rural to urban migration, thus relieving population pressure in cities. The World Bank also attributes rural energy projects with a more equitable distribution of resources, and services between urban and rural areas thus easing the human burden often associated with rural life (World Bank, 1975). In addition to a higher standard of living in a more equitable society, energy projects which feature a participation and self-help component also perform as a catalyst for other self-advancement programs. Therefore, a project may be a starting point for community rural development. Another latent benefit is the strengthening of local institutions that will be beneficial in other development programs.

Benefits related to renewable energy supply programs are presented in Table 3. The mechanism through which benefits are accrued are listed by three dimensions associated with energy projects:

1. Conservation of Energy - scarce resources will be conserved by adaptation of energy saving devices such as charcoal and wood burning stoves;[1]
2. Renewable Energy Substitution - the substitution of environmentally neutral renewable energy sources for petroleum, and environ-

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[1]A simple wood burning stove consumes 50% less fuel as compared to an open fire for the same BTUs. In areas using open flames for cooking, the adaptation of this technology would save between 20-30% of the total energy demand.

Table 3

Relationships Between Energy Projects and Potential Benefits

	Types of Energy Projects		
	(1) Conservation of Energy	(2) Renewable Energy Substitution for fossil fuels and Environmentally Destructive Energy Practices	(3) Increased Non-human Energy Resources
:conomic ıtional	less energy resource usage	decrease in dependency on fossil fuels and other scarce resources	—
ıg and :e	less time needed for gathering cooking and drying fuel	—	labor released by substitution of other energy sources for human power
ɔrovements	—	cleaner energy resources less smoke, less burning of dung decreases disease potential	lights and refrigeration for health clinics, lower caloric intake required
ity	indirectly thru time released by cooking fuel collectors	possibly indirectly thru use of more efficient energy sources	indirectly thru health improvements, directly thr time released, use of more efficient energy sources and increased energy per hectar and per man hour
ral nts	less demand for fuel from dung and agricultural refuse therefore these may be used for soil reconditioning and/or fodder respectively	a lessening of desertification due to fuelwood consumption	more efficient water lifting for irrigation, and other tasks in the food processing chain
in uality	indirect thru time saving: more leisure for other non-productive pursuits, decrease in fuel budget expenditures	if the substitution is cheaper then decrease in fuel budget expenditures, more environmentally pleasing surroundings	1.increased income indirectly from increased productivity 2. lessen human drudgery in farming 3.lighting in rural areas should broaden village life 4. increased leisure time 5. better and more efficie social service delivery system e.g.,school, healt clinics, family planning
Diversity	employment in production of conservation equipment	employment in production of the new technology devices	prospect in new commercia industries because of new energy power sources (backward linkages)
ɜntal	lessen pressure of the environment associated with fuelwood,charcoal, and dung	lessen pressure of the environment associated with fuelwood, charcoal, and dung	land reclamation
Rural to gration	—	—	indirectly thru increased quality of life and socia service
y of y Energy	—	acquisition of technology and equipment for harnessing solar energy	acquisition of equipment for harnessing various sources of solar energy

mentally damaging sources of energy (e.g. fuelwood consumption which has led to deforestation and increased desertification in many areas;[1] and

3. Increased Non-human Energy Resources - the increase in the level of non-human energy resource and usage in rural areas.

The first two project categories benefit not only the local target area but also have positive effects on the national economy. These types of projects ease the economic burden, associated with dependency on fossil fuels at the national as well as the local level. This is especially important to energy importers such as Jordan, Morocco, and Yemen.[2] Decreasing the domestic demand is also important for petroleum exporters in their attempt to avoid an economy dependency on a fuel source whose reserves are being depleted. At the local target level, conservation and petroleum substitution will lessen the financial burden from increasing fossil fuel and charcoal/wood prices. Projects of this nature will also bring these communities closer to the goal of self-sufficiency. More efficient cooking fuel consumption will also decrease the amount of time necessary in collection of non-commercial fuels. This release time, affecting primarily women, may be used for economic pursuits or intensification of household duties.

The third type of project which involves increasing the amount of non-human energy available to communities should be a high priority in development planning since

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[1] Fuelwood consumption is not inherently destructive, but this process occurs because of the overcutting of wood therefore increased production of wood (wood lots) is an acceptable renewable energy project.

[2] Although Egypt is a net exporter of petroleum, they import butagas (methane) for urban cooking fuel.

this is an essential ingredient in 1) the improvement of quality of life, 2) increased production, and 3) improvement in the terrain surrounding the village.[1] Improved quality of life of the poor is the major mandate for AID supported projects and is considered by most scholars and practitioners of development the end objective. Increased available energy relieves people of the drudgery of physical tasks associated with agricultural production. In addition, increased increments of non-human energy will increase productivity in agriculture as well as village crafts and small manufacturing enterprises. More energy substituting for human efforts increases leisure time for other activities. It may also provide lights for evening recreation, work and reading thus broadening village life. Energy for water systems, space heating, or to provide clean, hot burning fuels in lieu of slow burning unsanitary cow dung are all potential benefits. Solar collectors may also be used to heat water cheaply to provide hot water for washing clothes and bathing.[2] In addition, these increased energy sources provide an important component for the increased quality of social service delivery systems such as health clinics and schools.

The second proposition is that increased energy utilization will increase productivity. Two major sources of increased productivity result from released human en-

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[1]The following discussion of these issues is adopted from an article by James Howe of ODC in a monograph entitled "Energy for the Villages of Africa," 1977.

[2]Use of already heated water in cooking can save up to 50% of fuel necessary for cooking.

ergy applied to other activities and the increased efficiency obtained by augmenting human power with various other energy sources. The time releases attributed to substitution of mechanincal (wind and water power), electrical and animal traction technology for hauling water, planting, harvesting, and processing crops may be devoted to other economic related activities. For example, some of the released time might be devoted to more intensive cropping, more cultivated areage, better care of livestock, and greater effort in crop processing and storage thereby increasing output. Other efforts may be devoted to such non-agricultural productive activities as handicrafts and small manufacturing. This new energy could increase production by providing heat needed for more efficient and better crop drying and machines to cultivate, thresh, and shell more effectively. Renewable energy could pump water for irrigation and reclamation of new lands. A more efficient means of cooking would decrease demand for cow dung and agricultural residue as fuel, thus increasing their availability for soil reconditioning. Also new energy devices could provide power for lathes and other tools for small industry.

The third proposition is that new sources of energy can help save the terrain surrounding the community from being stripped of vegetation used as fuel for cooking, crop drying and other purposes. Alternative solar energy sources would reduce this need of organic fuel and thus permit vegetation to grow which would protect against further erosion and maybe even reverse the desertification process occuring throughout the Near East. These benefits accrued from energizing rural areas are a strong case for making new renewable sources of non-human energy available to the villages and farms in the Near East. Very few other development projects give this degree of emphasis to rural

areas, to agricultural productivity, to labor intensive capital saving investments and to meeting the basic needs of the poor majority.

The following section outlines a methodology for the planning and designing of renewable energy projects. This methodology addresses the non-engineering components of implementation and technology design in an effort to increase appropriateness of the energizing process.

The Near East is considered climatically the most favorable region of the world for solar energy adaptation.[1] Fuelwood production is the least feasible source of indirect solar energy for this region.[2] Wood plantations' direct competition with food production in the use of scarce productive lands is obvious, but also, if land use is intensified for bio-resource farms, this will require large amounts of fertilizer presently not available in surplus supply. Small decentralized hydro-power (electric conversion and mechanical) also has limited utility in the Near East setting because of the general lack of year-round reliable rivers with appropriate typology. This source should not be ruled out entirely; mountain areas of Morocco and Afghanistan have ample potential for hydro-development.[3] The four most regionally appropriate renewable energy sources and technology are:[4]

--Windmills: For thousands of years wind has been harnessed to propel boats and ships and to provide rotary windmill power to augment human labor. Ancient Egyptians used windmills as early as 3600 B.C. to pump water for irrigation and to grind grain.

Windmills, where the proper wind conditions exist (minimum wind velocity of 6mph), can take over many of the tasks performed by villagers. Thru generation of

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[1]AID funded solar application research and implementation are in Egypt, Tunisia, Yemen and Jordan and planned for Morocco and Syria.

[2]Morocco is planning research with fuelwood plantations utilizing land unsuitable for agricultural purposes. The question is whether or not this marginal land could be reclaimed with intensified renewable sources, i.e. irrigation pumping and fertilizer produced by bio-gas digestion connected to urban sewerage. Resource planning must be a Gestalt approach.

[3]The DOE Egyptian energy survey stated that Egypt has already reached its maximum potential from hydro-power.

[4]Most of the data present in this cursory review of technology is taken from National Academy of Science volume Energy for Rural Development (1976).

mechanical and electrical energy (1 KW to over 1 MW) they can pump water for irrigation and domestic use, power crop processing devices for grinding and threshing, cut wood, and generate electricity for a variety of purposes.

Most commercially available windmills sold today require little maintanance (annual inspection and lubrication) and are built with an expected life of 10-20 years.

In addition, there are a number of windmill designs that villagers can construct using locally available materials. However, these units usually require more maintanance and operational labor.

It is impossible to give detailed cost estimates for this technology; the range is extremely large ($1,000 to 10,000 per KW) depending on the model, purpose, and power generation capacity. In general, electric generators and larger units are the lowest priced.

--Generating Methane Gas from Organic Wastes: The second proven technology is the generation of methane gas from organic wastes. Biogasification involves the fermentation of animal dung, human excreta, and organic farm and household debris and wastes in relatively air tight tanks, to produce methane gas. An equivalent of 4 KWh of methane per day can be generated by one cow. The gas may be used directly for cooking and lighting or as fuel for electric generators. The NAS sponsored workshops on Solar Energy for Tanzania estimated that energy can be provided by bio-gas plants at one-tenth the cost of diesel generated electricity.

The process leaves a residue which is a liquid fertilizer in partially sterilized form which contains all the nutrients present in the original organic material. The fertilizer may be dryed and then applied or may be mixed with the irrigation water.

The technology is known and reliable particularly where livestock are abundant, and has been used by thousands of farmers in Korea, Taiwan, China, and India. Egypt has selected villages for pilot projects to start by 1980. There are problems with consistency of output during the cold season in high latitude or high altitude areas, but this may be corrected by use of flat plate solar heat collectors to maintain proper temperature in the fermentation chamber.

Bio-gas digestors are also advantageous for public latrine connection since the slurry by-product is sterilized by the fermentation process.

The degree to which biogasification can be accepted and used will depend heavily on both the number of sedentary cattle or other animals from which dung can be collected and/or availability of other forms of organic waste. Also, villagers must be willing to collect and handle dung. Most family size bio-gas units require dung from a minimum of four cows.

Village scale use would require a substantial degree of cooperation involved both in collection of organic waste and in distribution of gas and the fertilizer by-product.

--Photovoltaic (pv), or Solar Cells: The third proven technology is photovoltaic (pv), or solar cells such as those used in space crafts. These semiconductors are usually made of wafer thin slices of silicon attached to wires and covered with or imbedded in glass. The action of the sun on these cells creates a continuous electric charge which is collected and carried off by the wires. Theoretically, given the available sun radiation in the Near East, 5.5 KW hours of electricity is generated per day for each square meter of surface. Although fabrication technology is sophisticated, it takes virtually no technology to maintain solar cells since there are no moving

parts. Expected life-time of pvs could be indefinite. Solar cells operating for ten years show no sign of chemical deterioration. The electric charge is DC which may be used directly or converted to AC current. If direct current is used there is the possible danger from electrocution since contact with DC as compared to AC usually results in death.

--Simple Flat Plate and Concentrated Solar Collectors: The forth technology is the simple flat plate solar collector, an insulated box painted black on the inside, and covered with glass. The glass lets the sun's rays through where they convert to heat on contact with the black paint and the glass traps the heat from escaping. That heat can be used to dry fish, grain, or tobacco; distill water, power refrigeration, heat water, and run a pump among other things. The technology for most uses does not require great skill either to construct from local materials or to maintain and operate. For intensified heat, parabolic solar collectors are used which beam the sun radiation to a collector. This technology is primarily applicable for industrial needs for high temperatures.

A sampling of equipment and devices for utilization of these solar technologies is presented in appendix A. All these devices provide assistance to urban and rural areas to lessen their dependency on fossil fuels and provide often for the first time a technology to rural villages for assistance in food production and improved acquisition of basic subsistance needs such as potable water, and improved and health care facilities.[1]

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[1]Improvements in health impacts may occur from better nutricien due to improved food drying techniques and increased production. Bio-gas digestors will eliminate pathogins in human excreta. Also, along with other reasonable technologies improve the physical facilities of clinics by providing energy for light equipment and refrigeration.

In addition, these technologies are available and applicable to people wherever they live, in remote villages as well as urban centers. These systems also allow for a piecemeal approach, where systems may be added to indefinitely as demand increases and financial resources become available.

III. A Methodology for Energy Project Planning:

The general goal or criteria for energy related planning are projects designed for development of more efficient renewable energy resources and programs to increase the efficiency of traditional and renewable energy utilization.

The degree to which these goals are accomplished in a project's implementation is determined by the planning methodology and subsequent project design. The approach present in this section provides a focus toward planning based on the expressed needs and desires of the target population.

Once engineering hardware has been designed, planning for the implementation must be based on economic and social feasibility studies in an effort to select the most appropriate technology for a given energy demand situation.

Some energy projects require more attention to the social environment than others. This is usually directly related to the amount of behavioral and attitudinal changes required for sucessful technology adoption.

The planning methodology for determining appropriate project designs and technology implementations requires a three step process.The first two are concerned with resources demands and supply feasibilities. Third is dependent on an understanding of the technical and economic constraints of the alternative technologies/equipment and the social feasibility of the proposed implementation process. This three step process involves:

- an inventory of energy related community tasks and needs ,
- a community energy resource assessment, and possible resources in cost-effective manner acceptable to the inhabitants of the community.

The degree to which benefits materialize depends on the careful attention given to each of these steps by

project planners and the extent to which community based groups are involved throughout the project planning and implementation stages. Energy programs which are not planned from the beginning on local realities and the expressed interest of the villagers will waste money,possibly increase inequalities and eventually its capital components will fall into disuse and become one more piece of equipment littering the countryside.

The first part of this section expands on the essential social analysis requirements for project design. A dichotomy is presented for the design of a social soundness studies with a general guideline for determining the intensity of behaviorial changes necessitated by various types of energy related projects.

The second part is a detailed discussion of the proposed planning methodology for energy project design. This methodology is based on the three basic steps outlined above. The last sub-section is a brief discussion of various social issues that must be analized in any energy project.

A. Social Assessment of Energy

Social analysis of energy projects must include two dimensions, a social profile and a social feasibility study. The social profile includes an identification of the beneficiaries and the baseline data to be used for later evaluation. The social feasibility or soundness study is designed to assist project planners in the identification of communities' capital absorption abilities. The feasibility studies will also assist in the selection of the most socially acceptable implementation procedures by identifying social parameters which affect this projects local acceptance and ultimate success. It is this aspect of social analysis that determines whether the engineering solutions are appropriate given the social environment and

what behavioral changes must take place for successful implementation. Therefore, it is important for a social scientist familiar with energy related systems and problems to be formally involved in the initial planning stages of all energy projects. In fact, early involvement may lead to a joint identification of alternative interventions that need to be examined. The project design procedures as discussed in part B assume the involvement of a social scientist in early stages of project development. This process also requires community participation in various phases of project design. It is attention to these social elements that determine the project's acceptance, utilization and ultimately its absorption and success in terms of community quality of life impacts.

Certain projects require more individual behavioral changes and project acceptance than others. These active interventions as compared to passive ones require more careful attention to social elements. With regards to energy projects there is a tendency for rural projects as compared to urban ones to require a more active intervention strategy. Also, in general terms, projects which introduce conservation technologies also require a more indepth and sensitive social feasibility study. Table 4 is a classification of energy technology by the degree of behavioral changes necessitated by the intervention. Active interventions are projects which require substantial behavioral and attitudinal changes while on the other hand, passive interventions require very little change in traditional folkways. A general social analysis checklist or guideline presented in Appendix C provides assistance in the preparation of the Social Analysis Statement.

This statement is an essential component in the project design methodology discussed below. The checklist (appendix C) provides data for determining the final design and implementation procedures.

Table 4

Classification of Energy Intervention by Degree of Associated Behavioral Change

	Active Intervention	Semi-active Intervention	Passive Intervention
A. Renewable Energy Resources			
Solar Cells (Photovoltaic)			X
Other Solar Collectors (Flat Plate and Concentrating)			X[1]
Solar Conversion Rankin & Sterling Engines			X[2]
Wind (Mechanical Generator)			X[3]
Hydro-electric			X[3]
Bio-conversion Wood/Charcoal, Pyrolysis	X[4]		
Bio-gas (Anaerobic Digestion)	X[5]		
Draft Animals		X[6]	
B. Conservation			
Solar Cookers (Simple Models)	X[7]		
Wood and Charcoal Burning Stoves			X
Bio-mass Plantations		X[8]	
Electric and Gas Stoves			X[9]
Solar Pre-heated Water for Cooking		X[10]	

[1] may require manual sun tracking, All solar collectors require room or space for collector. Collectors on roof may compete with living space. A hot water solar collector will take up about one-half of the roof. This problem could possibly be avoided by design that places the collectors on sides of buildings (e.g., canopy arrangement) or location of collectors on posts above the roof tops. If chemical fluids are used for heat transfer care must be taken when flushing the system and checking for leakages.

[2] maintenance and oiling

[3] minor maintenance. One remote danger which must be guarded against thru routine inspection is loose blades which may fly off the windmill.

[4] requires harvesting and collecting of wood and wood fibers. This requires cooperative activity and delegation of work.

[5] requires the collection and handling of animal dung and possibly human excreta. Also, requires farmers to collect and deliver agricultural residue. This would be residue which could not be used as fodder such as cotton stems.

[6] care for animals and use of new tools only minor behavioral changes in animal usage

[7] requires new cooking techniques and time of cooking

[8] land tenure constraints, management and resource allocation problems

[9] gas stove requires less change because there is still flame for cooking

[10] using pre-heated water in cooking will save about 50% of the required fuel for cooking, some education required

B. Design Methodology for Energy Projects:

To reemphasize, the basic design procedure for an energy project should be developed from a three step process. The first step involves a community energy related task and needs assessment. [1/] At this point a detailed list is developed of all tasks performed in the community with their present associated energy resources. These tasks may be divided into general categories of economic, household, leisure, and community social service activities.[2/] In rural or low population concentrated areas, economic activities include agricultural, livestock and dairy, handicrafts, and small industries and businesses. The other three categories would be very similar for both urban and rural areas; differences being types of energy used or absences of tasks due to a lack of appropriate energy sources. Also helpful at this stage is the community's preference and prioritization for additional and substitutional energy sources to assist in these tasks. This phase of community involvement is important if projects are to be designed to meet the community's expressed need and desires.

The second step consists of an energy resource assessment for the community. This requires data to be collected on the potential alternative renewable (solar) energy sources. These data include wind velocity, water flow rates, sun radiation intensity, quantity of organic waste, and animal

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1/ This task assessment is performed for individuals, households, and community.

2/ A generalized list of some of these tasks is presented in Table I, page 7. This list will be helpful in developing a community specific listing.

traction potential.[1/]

The first approximation may be improvised by use of the Beaufort scale (appendix B) for wind or solar radiation based on temperature and cloud coverage. Both of these techniques have produced results within 10 to 20% of real values. Also, if a Pyranometer (solar radiation recorder) is nearby, village sites with similar typology may be assumed to have similar radiation readings. Much of the climatic information for the Near East is available from The National Climatic Center in Ashville, N.C. and The World Meteorological Organization. In fact, a computer program could be designed which would assist in site selection by identifying those areas where sun radiation, water

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1/ Makhijani and Poole (1975:75) maintain that a draft animal can contribute between one-third to one-half horsepower capacity for 300 to 1,000 hours per year. This enables the farmer to either use his land more intensively, relieve peak labor problems, or expand the cultivation area by 100% for small holdings. The one major drawback for the Near East because of the fertile land scarcity is that Howe (1977) estimates that for every acre or so that may be cultivated by a draft animal requires around a third of an acre (including fallow land, stubble, agricultural refuse, and non-cultivable hillsides) set aside to feed the animal. When draft animals are used in conjunction with bio-gas digester, trade-off of fuel usage will possibly alleviate land scarcity problem. Agricultural refuse can be used as fodder instead of fuel and dung produced can generate methane gas as a fuel substitute. In addition, the bio-gas digester will produce a slurry for fertilizer. With a combined approach, draft animals could become an important source of non-human energy.

currents and/or wind velocity is sufficient to power various solar technology devices.

The third and final stage, interfacing of the task and new energy sources in a manner acceptable to the community[1/] is where the difficulty lies in designing energy projects which provide appropriate energy assistance for specific community desired tasks. Unlike more traditional energy sources, the appropriate match between needs and technology in the newer renewable energy field has not yet been firmly established. Therefore, there is an urgent need for continued pilot project testing and evaluation. According to Howe (1979) these village tests should be designed to answer six questions:

1. How well does a given device perform technically within the physical conditions - including the all-important variable of settlement pattern - of the village?
2. How does its cost compare with alternative energy technologies?
3. How does it fit the local culture?
4. How does it match existing or prospective village institutions that could own, operate, and maintain it?
5. What can be learned about the best techniques for introducing the technology into the villages?
6. What is the effect of the increase in available energy upon such indicators of community well-being as literacy, infant mortality, income, migration, and birth rates?

1/ This interfacing must consider the cost-effectiveness of various alternatives. This will be discussed at greater length later in this section.

The interfacing of technologies for a variety of tasks is very promising. This potential is described in Table 5, where 12 technologies are applied to 15 common tasks or needs. Forty-six of the applications are useful and 44 have marginal utility. As technology research and development continues more of these possible applications will increase in their utility. As is apparent from perusal of Table I, page 7, (a list of energy related tasks) not all tasks can be energized at the same time. Selection will have to be made for conservation, energy substitutions, and application of increased non-human energy. As implied from step three this selection should be based on the principle of community participation. Therefore, the final choice of technology should be based on:

1. The particular tasks communities wish to have energized (increases or substitution of non-human energy) and
2. the kinds of hardware communities prefer.

Taping these two community preferences is a primary ingredient in any social feasibility or soundness study. (See appendix C). Only if the project is designed around expressed needs of the community will technologies be accepted and utilized. Of course, as in all capital investment projects certain constraints must be imposed in determining the available list of choices. Short listing of choices or feasible technologies and devices associated with desired tasks should be determined by application of each technology and/or device to the following process of elimination:

First technologies must be based on a reliable and technologically accessible source of energy.[1/] Second, technical designs need to be based on the financial

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1/ Since one of the goals is to decrease dependency on fossil fuels, energy source should not be petroleum unless this project component is considered as an intermediate step with plan for petroleum substitution in a few years.

Table 5

Renewable Energy Applicability Matrix *1

Symbols: ++, applicable; +, marginally applicable; -, not applicable.

Solar technology	Energy Use														
	Water pumping	Lighting	Cooling Refrigerat.	Communicati	Water desalting	Spinning	Sawing	Heating: Cooking	Heating: Space	Heating: Domestic water	Grinding	Drying	Transport	Fertilizing	Tilling of Soil
Solar cells (Photovoltaic arrays)	++	+	+	++	-	+	-	-	-	-	++	-	-	-	-
Flat-plate collectors and solar stills	++	-	++	-	++	-	-	+	++	++	-	++	-	-	-
Concentrating thermal collectors	+	+	++	++	+	+	+	++	+	-	++	-	-	-	-
Solar, Stirling *2 (small scale)	++	+	+	+	-	+	+	-	-	-	+	-	-	-	-
Solar, rankine *2	++	+	+	-	-	+	+	-	-	-	+	-	-	-	-
Wind (mechanical)	++	-	-	-	-	+	+	-	-	-	++	-	-	-	-
Wind generator	++	++	++	++	-	+	+	+	+	+	++	+	-	-	-
Water (mechanical)	++	-	-	-	-	++	++	-	-	-	++	-	-	-	-
Hydroelectric	++	++	++	++	-	++	++	+	+	+	++	+	-	-	-
Bioconversion wood/charcoal	-	+	-	-	+	-	-	++	++	++	-	++	-	+	-
Biogas	++	++	+	-	-	-	-	++	+	+	-	+	+	++	+
Draft animals	++	-	-	-	-	-	-	+	-	+	++	-	++	++	++

*1 This matrix is an adaptation of a table presented by J.R.Williams, at the workshop on Solar Energy for Villages of Tanzania, Dar es Salaam, TAnzania August, 1977.

*2 Rankin and Stirling engines for steam, mechanical, and electric conversion are not feasible in most rural settings due to the technical level of operation.

resources available to inhabitants of the target area (i.e. is the system financeable given its capital and operating cost and what are the incidence of finance). An important consideration is the project's financial burden for the citizens and country or region as a whole. Another component in the financial consideration is a comparative analysis (cost-effective analysis) of alternative technologies for particular tasks. This is basically a qualitative approach to identify cost against benefits. The technique would be useful in determining the final short-list of options with the least-cost and maximum benefits.[1/] Finally a technical assessment must be made of each possible system still under consideration. These technical factors of consideration are:

- the technological equipment's feasible and optimum size compared to the community's present end forecasted demand
- the system's ease of maintenance
- the system's reliability
- the environmental impact from utilization of the proposed technology
- the feasibility of local manufacturing of system components
- the expected course of future technologie's development

1/ Cost-benefit analysis has only limited utility in planning rural energy projects for conservation and increasing non-human energy resources, because a major portion of these benefits are not qualifiable in monetary terms. For example, what value should be placed on energy self-sufficiency or release from drudgery of manually hauling water, tilling the soil, processing grain, etc. Even increased health has little economic value in highly underemployed regions.

- the capital absorption capabilities (e.g. human skills and physical resources constraints). And finally,
- the social and cultural suitability.

The last technical factor, socio-cultural suitability, will usually be taken into consideration during the community participation process. In this process planners determine target population preferences and thru extension and demonstration assist the community in decisions about hardware selection. This process is often not an easy one if community resistance to certain hardware is extreme and project planners are convinced this hardware is a necessary component in the energy plan. But if these differences are not assimilated before implementation the questionable hardware will probably fall into disuse.

Socio-cultural suitability is a very broad area of concern.[1/] Thechnological devices could be unsuitable themselves or the institutional requirements for utilization of these devices is not applicable to the community social setting. The best way to discuss these issues is to give some examples:

1. Solar cookers have not been accepted in most communities because they require food preparation to be performed during sunlight and preferably during the mid-day. This does not meet farming communities' eating schedules which require cooking a large breakfast and a late supper. Also village

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1/ Some of the important dimensions of these issues are presented in Appendix C, social analysis checklist specifically in part II, the social feasibility. Also see discussion in part A of this section.

women must cook in the sun instead of the shade or indoors. These cookers are also best utilized by families who cook their meals in one large pot.

2. Many of the technological devices are best suited for community level usage due to their energy optimum output. In this situation communities will be required to co-operatively use and maintain the equipment.

3. Bio-gas digeston which plans to utilize animal dung will require village handling of dung. In some cases this may be a taboo or to a lesser extent considered filthy. Sometimes extension program can work out a solution but if a solution is not found this technology can not be successfully utilized.

4. Since many energized tasks are dependent on solar heat, tasks performed by men in the late afternoon may have to be done during morning or mid-day hours. This may require men to switch their time schedules or have women perform these tasks. One of these solutions of both may not be acceptable folkways. As above, these folkways may be changed thru extension and educational intervension, but if these interventions are not successful another technology will have to be used.

Discovering these cultural constraints requires a level of sensitivity on behalf of planners and an intensive participation on the part of villagers in hardware selection and implementation designs.

In summary, the decision process or steps to be used in project designs and technology selection for energy substitution and increased non-human energy availability is as follows:

- a survey or assessment of energy related tasks and their associated present energy sources

- a survey or assessment of possible energy resources available to the community. These could include wind and water power, sun radiation, draft animals, and bio-mass [1/] including both vegetation and animal-human waste, and,
- interfacing of feasible resources with tasks in a manner acceptable to the community.

This third key step is further divided into a series of sub-operations necessary to produce this successful interfacing. Various components of these procedures involve a good deal of community participation if the final product is to be successfully utilized and accepted. Sub-divisions of step three include:

- determining from the community which task they prefer to have augmented with new sources of energy and/or substitute process and these energy priorities.
- a technology financial assessment based on available resources, and hardware preferences of the community; and finally,
- a technical feasibility assessment including optimum size, maintenance, reliability, environmental social suitability, and capital absorption capabilities.

This procedure will assist in more efficient planning and thus increase chances for sucessful projects meeting the needs and desires of the community.

The next section will address some of the key issues

1/ Bio-mass includes a variety of technol.gies includig woodlots, charcoal production, Bio-gas digesters, and pyrolysis.

in energizing communities of the third world. These issues must be considered early in the project design if acceptable solutions are to be found.

C. Social Issues for Consideration in Project Design

In project designs and implementation processes there are a series of socio-institutional issues that must be addressed. Some of these situations may be improved thru the design mechanism and early direct planning if planners are aware of the potential problems or issues. A partial listing of some of these issues is:

- The equity constraints associated with any capital development project (cost). Renewable energy technology is expensive and front end loaded. Although the technology may be cost effective over time and provides a needed function in the development process, the initial cost is prohibitive to the poor. Therefore, the technology must be subsidized and/or provisions made for long-term low interest loans. These technologies require very little operating cost and the only recurrent cost for many systems is the energy storage systems.[1/] Therefore the only financial constraint is the initial acquisition of the devices.
- The equity problem associated with energy commercialization. If energy projects are oriented toward family acquisition, this could result in a negative budgetary impact for the poor. This is especially a potential in family owned bio-gas digestors and wood lots. For example, in Indian

1/ These storage systems are based on batteries which must be replaced every three to five years. Not all systems will require energy storage capacity.

villages, family owned digestors created an economic value for the organic waste inputs. Therefore, the poor were restricted from gathering cow dung and agricultural refuse from the fields for free. This forced them to buy methane gas and convert to gas cooking burners. This commercialization of a once free energy source is a hardhip on the poor. Project suggestions would be to either plan for community run bio-gas digestor and wood lots or an arrangement in which poor families could provide labor such as dung collection in return for free or subsidized gas.

- The Institutional problems in acquisition and operation of the technology and devices. Due to the cost and optimum generating capacity, some of these technologies (e.g., bio-digestors, solar and wind driven pumps, and electricity generating devices) will need to be designed for community utilization. In some communities there is a tradition of cooperative activity but in others where this tradition does not exist will require more extension services in establishing the organizational structure. Where cooperative organizational structures do not exist the project can help establish a village organization to operate and administer the project or they can use an organization from outside the village structure for equipment operation and maintenance. The first option would probably be the choice for rural areas while urban areas would operate better with an outside structure like a city energy commission. Some technologies are easily adapted to private enterprise. For example, a bio-gas digestor where entrepreneurs buy dung and refuse from farmers and sell the gas and fertilizer at a profit. Similarly,

solar driven grinders and dryers could be owned and operated by individuals for profit. The social analyst needs to consider all possibilities for the best institutional arrangement within the community for owning and operating various devices. In situations of village ownership, project designers must also decide with help of the community a system of family usage. Is grinding performed together or does each farmer do his own? Who can use the grinder and when? All these decisions must be worked out equitably in advance of implementation to avoid possible conflicts later.

- The effect of time saving devices on the family and village. This is a major component in the impact study. Is there a potential for other economic pursuits and if so does the project need to give assistance in their development? Many of the conservation and water pumping components in a project will give release time to women. The analysis cannot assume that women will benefit. In many societies women have little control over their time. If they experience release time from a project, their husbands simply reassign family duties, thus women find their time void has been filled with other duties. Educational exemption programs may be able to influence this duty assignment. Possible domestic assigments may increase time spent for child rearing and household hygiene or women could become involved in economic pursuits.
- The projects acceptance and the community's willingness to participate. The designs formulated in this paper are based on the principles of community participation. Only thru this type of project design and implementation can planners be assured of some

success. From extensive African experience, alternative energy technologies were found to be more acceptable when:

- they required little behavioral changes
- villages were given proof that the new technologies were efficient and economical
- costs were kept to a minimum
- project uses and strengtens local political and/or indigenous organizations wherever possible. If new organizations must be developed, they are formed in a manner not to lead to a power struggle in the community; and, most important,
- extensive dialogue existed between donors and receivers resulting in the community having control over the technology and designs.

There are four major points at which local population may play a significant role in the decision making process. First, simply which task if any they would like to have energized and what types of conservation projects are of interest. Second, the community may become involved in the selection of technically feasible alternatives based on their perceived needs and preferences, subject to local and national constraints of financing and manpower. Next, the community may be involved in setting pricing policies or forms of contributions. Less problems in payments occur when the community at large has been involved in setting up the pricing schedule to suit their income flows. Finally, the community should be involved in setting up the social controls for continued use and maintenance. Local management policies will be more effective if they are adjusted to the community network system and their formal government structure.

All of these activities further commit the community to the project and its operation maintenance.

A survey commissioned by UNICEF-WHO (ICEF/6.1355) and Rowland (1978) delineated a set factors that appear to have been favorable to community participation in water supply projects. Some of these same factors applied energy projects should also have similar effects on community participation. Seven of these factors which could be applied to energy projects are:

1. Participation increased by 21% when projects were requested by village leaders, or groups representing the village after village meetings approved the project.

2. Specific government policies to encourage village involvement were found to enhance the extent and depth of participation.

3. Maximum participation occurred when limited local resources were complemented by external resources, especially those provided by government. This could be in the form of technical advice and knowledge. Especially if experts work closely with locals and are sensitive to local concerns, traditions and values.

4. Participation was higher in areas where government utilized a decentralized administration and practiced regional planning.

5. When local leaders have been cooperative and support the project, they are a dynamic force through which community activities are initiated and sustained.

6. Participation has increased when mobilization

processes revolve around tradition (e.g., cooperative efforts are often traditionally associated, with certain seasons like harvest; with leadership of certain individuals like chief; with certain philosophies like giving assistance to the village).

7. Higher levels of participation were associated with a short start-up period. Enthusiasm decreases with the time span between planning and implemention.

Project planners should therefore attempt to incorporate as many of these factors as possible in their planning process. Based on past experience this should increase chances of success, with projects becoming a source of pride for the community and therefore utilized at the maximum capacity.

Petroleum subsidies affect the rate of adoption of new technologies. If new renewable sources of fuels are to be cost competitive with fossil fuels, governments must either decrease petroleum subsidies or apply similar subsidies to renewable energy resources. Since these renewable resources are based on technologies for harnessing a free energy source (e.g. sun, wind, falling water, etc.), the technologies must be supplied in part with government funds or the provision of low interest, long term loans for acquisition of the technological devices. These loan or grants would off-set the comparative cost disadvantage between fossil fuels and the alternative resources.

D. Conclusion.

This document has developed a general guideline to assist energy project planners. These programs should be based on addressing the deteriorating economic position of communities due to current energy supply-demand problems

and development requirements to improve energy utilization. This is accomplished by investment in energy projects which adopt more efficiente and environmentally acceptable energy sources and those which increase the efficient utilization of traditional and alternative (renewable) energy.

The project design methodology outlined in this paper will assist planners in identifying crucial social constraints in energy project designs.[1/] The methodology guides planners thru a stepwise procedure which will enhance the planning process for better project designs addressing the energy needs of the target population.

1/ This approach requires an intensive level of community participation and more direct sociological/ anthropological involvment in the project design phase.

Appendix A

Solar Energy Technologies

- Solar Water Heaters:

These systems transfer heat to water as the sun's rays are absorbed by metal sheets or tubing. Use of such systems is already widespread in Japan, Israel, and Australia. Near East cities could benefit from this technology to provide for all of their hot water needs. By use of solar concentration water could be heated to the boiling point for industrial needs. In rural areas, heated water will conserve cooking fuel. In 1975 only 5% of the total Egyptian population had water heaters and those were fueled by butagas. Presently hot water needs are provided by heating small amounts on the stove. Cooking with hot water would save about 50% of the cooking fuel required.

- Small-Scale Hydropower:

Both hydroelectric generators and water wheels for grinding can be made to village scale. These systems do not require huge dams. A turbine can operate simply from the flow of water. Most of China's rural communes rely on electricity produced in this way, and there is no technical reason why Near East mountain and high plateau villages and towns with rivers and streams nearby could not do the same. A number of small-scale units have already been installed in Africa and in the mountain region of Morocco. Experimentation will start in the near future.

- Solar Drying:

Crops and fish have always been dried by the sun. The use of simple solar collectors can speed the process while protecting the food from wind, rain, insects, rats,

and birds. The faster process will decrease the amount presently lost to spoilage.

- Solar Cells:

Among other things, the space age has given us the solar cell, which makes electicity straight from sunlight. To produce a watt of power from midday sun requires solar cells which should cost but 50 cents by 1985, bringing electricity for high-value uses within the reach of every village. Already, experiments in using solar cells to pump water are being carried out in Tunisia.

- Wind Power:

Wind machines can be used to grind grain, pump water, or make electricity. The coastal regions of the Near East produce winds of sufficient force for these machines to be worthwhile.

- Solar Cooling:

There are various techniques for using the sun to cool space for living or for storing food. Solar collectors are used to heat the refrigerate. Solar cells are being used for refrigerators in some medical clinics in Africa. But the use of sclar flat plate collectors is a cheaper technology. Although these technologies are less well developed than other devices listed here, they have considerable promise for the future.

- Solar Stills:

A simple still consists of a flat evaporating tray covered with a single inclined glass (L shape) or two inclined glass covers like a roof. Solar radiation warms the brine in the tray producing evaporation with

vapor collection on the glass. The vapor condenses and slides down into collection channels.

- Solar Food Cookers:

A recent study found that "Although programs to develop solar cookers have been actively pursued for over 100 years, they have never found acceptance at the village level." (J. Walton et al., 1978:p.iii.) There are abundant social and economic reasons why this should be so. Nonetheless, experiments continue in the faint hope that some use can be found for these systems.

- Biogas:

Through a fermentation process, organic wastes are converted to an odorless liquid fertilizer and methane gas for cooking and conversion to electricity and mechanical power. Some advantage of this technology is that fertilizer volume or nutriments have not been reduced by the process. Also, the process effectively kills pathogens that were present in the original human excreta. Extensive experience in China suggests that family-scale methane systems can be constructed for as little as $15.

- Solar Pumps:

By boiling liquids, the heat from the solar collectors can be made to turn turbines and pump water, although currently quite expensive.

Appendix B

BEAUFORT SCALE OF WIND FORCE
(Compiled by U.S. Weather Bureau, 1955)

Beau-fort number	Miles per hour	Knots	Wind effects observed on land	Terms used in USWB forecasts
0	Less than 1	Less than 1	Calm; smoke rises vertically	
1	1-3	1-3	Direction of wind shown by smoke drift; but not by wind vanes	Light
2	4-7	4-6	Wind felt on face; leaves rustle; ordinary vane moved by wind	
3	8-12	7-10	Leaves and small twigs in constant motion; wind extends light flag	Gentle
4	13-18	11-16	Raises dust, loose paper; small branches are moved	Moderate
5	19-24	17-21	Small trees in leaf begin to sway; crested wavelets form on inland waters	Fresh
6	25-31	22-27	Large branches in motion; whistling heard in telegraph wires; umbrellas used with difficulty	Strong
7	32-38	28-33	Whole trees in motion; inconvenience felt walking against wind	
8	39-46	34-40	Breaks twigs off trees; generally impedes progress	Gale
9	47-54	41-47	Slight structural damage occurs; (chimney pots, slates removed)	
10	55-63	48-55	Seldom experienced inland; trees uprooted; considerable structural damage occurs	Whole Gale
11	64-72	56-63	Very rarely experienced; accompanied by widespread damage	
12 or more	73 or more	64 or more	Very rarely experienced; accompanied by widespread damage	Hurricane

APPENDIX C

Indicators (Variables) Checklist for Social Analysis of Energy Projects

Section I of this Paper developed two components for project social analyses. The first section consists of a community or regional profile including a discussion of the beneficiaries. The second component is a socio-cultural feasibility study. This statement must accompany all social analyses which are considered to require an active intervention role.[1] This social analysis guideline is developed with this dichotomy in mind. The first section will consist of indicators used for baseline data establishing the need for the project and the social impact or distribution of benefits and burdens among the different groups in the population.

The second section is a checklist of indicators and social parameters relevant to the assessment of the socio-cultural feasibility of energy projects. It is these social parameters that determine the project's acceptance, utilization and ultimately its absorbtion and success in terms of community quality of life impacts.

Whenever possible present the data in tabular form. Section I, part B, C, and D are especially easy to tabulate.

I. Social Profile and Beneficiaries Social Impacts

A. Demographic Survey: Present and Forecasted Change

1) Population density, Age distribution
2) Settlement typology and village size
3) Per Capita income
4) Measure of income equality - use of simple % is adequate

[1] Active intervention mode relates to those projects which require a substantial amount of behavioral and attitude changes for the project to provide an acceptable level of benefits to the community. Staff social scientists are the most capable in making this decision.

5) Mean years of schooling (level of education)
6) Schooling distribution - % categories
7) Employment statistics, includes breakdown of occupations - communities major source of income
8) Family size and average house size by socio-economic status
9) Migration statistics
10) Landholdings per family or unit of production and distributions
11) Market statistics; is there a local market in the community, size of market, how often?

B. Energy related task and energy needs

This section establishes the need for the project and the types of benefits that must be addressed in the physical design (ie the types of energy sources priority). This section will provide information for Step I of the project design.

1) Household-Domestic energy uses: Cooking

--Describe the cooking utensils/vessels
--Describe the cooking facilities by percentages (open pit fire, small stoves, etc.)
--number of meals prepared a day, and how often is food cooked
--How much time is spent cooking and by whom
--Time of day cooking is done
--Kind and amount of food cooked
--Cooking method - general type of food preparation
--Amount and kind of fuel used
--Method of obtaining fuel and who is responsible for its procurement
--Fuel cost

2) Household-Domestic energy uses: Heating

--If heating is needed - When and for how many hours
--Type of facility for heating
--Type of food used
--Method of obtaining fuel
--Fuel cost

3) Household-Domestic energy use: Lighting

--Type of lighting devices used
--What activities in general is lighting used
--Kind, amounts and cost of fuel

4) Household-Domestic energy uses: Water

--Where is water obtained and who is responsible for its collection. If from more than one source give percentages
--How is it transported from source to homes types of devices used for water lifting and fuel consumption - cost related to water acquisition
--Amount of water consumed (drinking, cooking, washing, etc.)
--Is there treatment for potable water
--Is there expressed concern about potable water quality and quantity available
--Amount of water heated and usage
--Fuel used in heating water, amount and cost

5) Household miscellaneous

--Types of appliance and amount of time used
--Fuel used - cost and acquisition

6) Agriculture energy uses: crops and crop patterns

--Major type of crops planted
--Size of agricultural holdings
--How are lands prepared - work tasks (give %) (hand tools, animal traction, tractor, etc.)
--Fuel and energy source required for these tasks and the cost
--Time spent on work task
--How many planting cycles in a year
--Type and quantity of fertilizer used and by what percentage of farmers.
--How often and how is fertilizer applied
--Cost of fetilizer

7) Agriculture : Irrigation

--Percentage of farmers and areas irrigated
--Irrigation process (flood, furrow, trinkle, sprinkler, etc.)
--How often is land irrigated
--Source and quantity of water used.
--Device from water lifting
--Fuel or energy consumption and cost

8) Agriculture: Crops processing and storage

--How are the crops harvested - process and equipment and by whom (family or cooperative activity)
--Type of crops processed
--Processing technology e.g., threshing, drying, ginding
--Devices used in processing
--Fuel or energy used (types, quantity and cost)
--What crops are stored and how
--What are the problems expressed by farmers about storage (e.g., spoilage - percentage and cause)

9) Transportation:

--Type of vehicles or transportation techniques, percentages
--Travel location - distance and number
--Purpose for which vehicles are used
--What fuels are used, where obtained and cost
--Description of transportation infrastructure

10) Commercial and Governmental energy consumption: <u>Buildings</u>

--Types of commercial buildings (hotels, shops,restaurants, etc.)
--Heating and cooling requirement
--Length of time lights are used and lighting apparatus (percentages)
--Their energy impacts (e.g., cook, food preparation, and storage)
--Social service buildings (schools,clinics) energy inputs
--Source of energy and where obtained
--Water demand for buildings - source, quality, and quantity used

11) Manufacturing consumption of energy

--Labor requirements # of hours per week
--Animal labor used
--Energy inputs - type of fuel, quantities, availability and cost
--Type of processing technology used

C. Present Energy Sources

Most of this data could be synthesized from Part B above. This data will establish the present supply schedule for energy and provide information for part of planning design step II.

1) What traditional non-commercial fuels are used in the area and estimated quantity demand (e.g., firewood, charcoal, dung, candles, agricultural refuse, etc.)

2) Which of these are free for collection and which are sold

3) What are the market values of these fuels

4) What is the average distance from the supply source for all traditional fuels used in the community

5) What commercial fuels are used in the community and estimated quantity demand (e.g., gasoline, kerosene, diesel fuel, butagas, etc.)

6) What is the cost of each of these fuels

7) Where are these commercial fuels sold and what is their availability

8) What percentage of the population is served by electricity and what is its cost

9) How many electric generators are in the community/area and how is the electricity generated - Is the source decentralized or from the natural grid

10) What is the operating time ie when is electricity available and the cost for electricity

11) Are draft animals used in this area? number and type

12) Have villages expressed any concern about availability of fuels

13) Over the last few months which fuel prices have been rising faster than prices of other staples

D. Potential energy sources (renewable energy). This section and section C above supply information necessary for completion of Step II in the project design procedure.

1) Draft animals:
--cost of purchasing draft animals and what types are available
--How much fodder would be available for agricultural refuse. What types of refuse are available
--How much uncultivated would be available for grazing. Why isn't this land cultivated.
--How many animals could be maintained on the feed sources

2) Bio-Mass: potential for bio-gas generation
--Number and kinds of domestic animals kept in the area
--Are the animals kept penned at any time and for how long?
--Is the dung presently being used and how?
--Who collects it?
--How many families own five or more draft animals or cows?
--Are there any cooperatives which own five or more draft animals or cows? approximately how many?
--Are there any fields of unused vegetation in the area that are suitable for bio-gas digestion? What is the value (do not overlook water plant growth in irrigation canals).
--What volume of Agricultural refuse is available for the digestion? (exclude refuse used for fodder).

3) Bio-mass: Wood lots
--Is there land available that could be used to develop a village woodlot?
--Is there any local experience in caring for trees (personal, organizational or traditional). If so, what was the outcome?
--What would be some of the obstacles in using the land for wood lots (e.g. water requirements, ownership, altitude)?

4) Wind-power
--What is the usual direction of the wind?
--On the Beaufort scale what was the highest gust of wind observed?
--On the Beaufort scale what is the estimate of the average daily wind velocity?
--Are there any seasonal differences in wind velo

city? If so, what are they?
--Is there local material available for tower and blade construction? type and size
--What related skills are available in the area
Mechanical work_____
Electrical work_____
Carpentering_____
Metal Work_____

5) Hydro-power:
--Is there a stream near the area and what is the typology (drop over a kilometer)
--Is there a natural place on the stream for a dam?
--What is the flow rate of the stream?
--What is the width of the stream?
--Does the stream run continuously throughout the year?
--How is the stream presently being used?

6) Direct-Solar radiation
--average number of hours of radiation per day by seasons
--usual number of hours per day of sun obstruction due to clouds
--What is the availability of land near task to be performed for solar collectors?
--What is the availability of rooftops for solar collectors?

E. Benefits and Beneficiaries

This section establishes the justification and assures that the benefits accrue to the poor majority. Table 4 in the body of the paper describes the benefits associated with the three basic types of projects. This should be used as a reference in addressing the benefit issues. This table presents generalized categories of benefits which may not be applicable to all projects. They should only be used as a guideline in the examination of benefits. Addtional concerns are listed below.

A) Community level benefits:

1) What is the impact on the economic growth potential of the community?
2) Are village organizations strengthened?
3) Does the project increase equitable distribution of resources?
4) Does the project establish important linkages with the government that may be utilized in solving other problems?
5) Number and percent of families in the lower socio-economic status served.

6) Changes in farming potential, types of crops, etc.
7) What are other community or regional benefits (e.g. environmental, employment)?

B) Individual level benefits (who is the target population?):

1) Number of people and/or households served.
2) What is the potential for increased income?
3) How much time will be saved from previous tasks, by whom, and how can or will this time be utilized?
4) Other specific individual benefits (e.g. health education).

II. Social Feasibility

The first subsection examines the behavioral characteristics of the target population. It is important to understand the changes in behavior necessary for communities to absorb new infrastructure and maximize benefits.

The next two subsections examine the structural and participation constraints.

The last section considers maintenance capacity of the community.

A. Cultural Setting - Values. Attitudes and Behavioral Characteristics

1) What do we know about the daily life or routine of the community in relationship to energy usage?
2) What changes will occur after the project and what are the expected new energy usage patterns?
3) What changes in or new kinds of attitudes and practices will the project demand? How are these to be accomplished?
4) What values, beliefs, attitudes and folkways (individual or organized practices of the community) might be utilized for the intervention and which ones may be constraints to the project?
5) If education and demonstration programs are a proposed medium for changing behavior patterns and attitudes. Describe the programs and how they will accomplish the goals. What experience have agencies had with these types of educational programs?
6) Would the residents prefer using different fuels than are presently being used? Why?
7) What tasks would villagers prefer assistance from new sources of energy? Are these the ones being proposed and is this assistance feasible?

B. Structural Constraints

1) Who are the critical groups of people and organizations to whom the project will have to be acceptable? Which groups are supportive? Who are the non-supportive groups and how may they be co-opted--will these non-supportive groups effect the project?
2) Are there any threats to existing social power? How are they to be dealt with?
3) Who is responsible for administration of the project (operation and maintenance)? Are linkages well established between the community and the administrative body?
4) What local, regional, and national administration organizations need to be strengthened? How is this to be accomplished?
5) Describe the educational component of the program and how it will accomplish: (a) necessary changes in behavior, (b) understanding of the expected accrued benefits, and (c) the maintenance and system usage skills.
6) What are the individual economic costs of the projects? Are they disproportionately high and thus will exclude the poor?

C. Feasibility of Participation

1) What active kinds of participation in decision-making, implementation or evaluation does the project expect among beneficiaries? (Will people be participating individually or in groups? What kinds of groups?)
2) Is there a tradition of such participation or previous experience which would ensure that it can take place? (Have the particular kinds of people that the project expects to participate, e.g. poor, women, been able to participate in the past under similar conditions? Will social norms and existing skills allow them to do so now?)

3) What are the social arrangements through which participation will be developed and channelled? (Have these arrangements taken into account different factions and conflicts among the target population which might hinder the effectiveness of such arrangements?)
4) What steps have been taken to improve participation (see section III, C)

5) What will be the institutional arrangement for ownership and operation of equipment. Is this equitable and acceptable to the community

6) Do the new energy resources produce usable energy that meets consumer preferences (e.g., usable at the desired time of day, cooks food in an acceptable manner,etc.)

D. Physical Maintenance Component

1) How are recurrent expenditures to be met? will this be adequate?

2) Describe the planning for maintenance manpower and training if necessary.

3) If a tariff structure is planned examine the ability to collect the fee. How are potential problems eliminated ans what is the incidence and effect of a usage fee on the poor's ability to pay? Also is the rate structure equitable?

BIBLIOGRAPHY

Brown, Norman L. (ed)
1978 Renewable Energy Resources and Rural Application in the Developing World. AAAS Selected Symposium Westview Press, Boulder, Colorado

Brown, Norman L. and James Howe
1978 "Solar Energy for Village Development" in Science Vol 199:651-L57 10 Feb. 1979

Cambel Ali et al - George Washington University
1978 Solar Assessment of On-site Solar Energy Technologies for U.S. Dept. of Energy, Washington, D.C.

Cecelski, Elizabeth
1979 "Cultural and Equity Constraints Conditioning Energy Usage" Paper presented to Ford Energy/LOC Meeting; Resources for the Future, Washington, D.C.

Choi, Harry Y. H.
1979 Indonesia: Productive User Programs of Rural Electrification Projects, AID/ASIA, Washington, D.C.

Darrow, Ken and Rick Pam
1976 Appropriate Technology Sourcebook, Volunteers in Asia, Stanford, CA

Dunkerley, Joy et al (Resources for the Future)
1979 Household Energy Use and Supply by the Urban and Rural Poor in Developing Countries, World Bank, Washington, D.C.

1978 "Patterns of Energy Consumption by the Rural and Urban Poor in Developing Countries" Paper presented to International Seminar on Energy, Hyderabad, India

Eckholm, Erik P.
1975 The Other Energy Crisis. Firewood. Worldwatch Paper 1, Worldwatch Institute Washington, D.C.

French, David
1979 The Economics of Renewable Energy Systems for Developing Countries - AID, Washingtcn

1978 Renewable Energy for Africa: Needs Opportunities, Issues. AID, Washington, D.C.

Graham, Thomas and Staff of Donovan, Hamester and Rattien,Inc
1979 Africa Energy Survey Nethodology - submitted to AID/AFR/DR, Washington, D.C.

Hayer, Denis
1977 a Energy: The Solar Prospect. Worldwatch paper II, Worldwatch Institute, Washington, D.C.

1977b Energy for Development: The Third World Option Worldwatch paper 15, Worldwatch Institute, Washigton, D.C.

Howe, James W.
1979 New Village Uses of Renewable Energy Sources Overseas Development Council, Washingtcn, D.C.

Howe, James W. and ODC staff
1977 Energy for the Villages of Africa Overseas Development Council

Little, Arthur O., Inc.
1974 An Overview of Alternative Energy Sources for LDC report to AID/OST, Cambridge, MA

Makhyani, Ayin and Alan Poole, 1975,
Energy and Agriculture in the Third World, Cambridge: Balliner

Organization for Economic Cooperation and Development
1977 Report by the Working Party of the Council to Develop a Co-ordinated Effort to Help Developing Countries Bring Into Use Technologies Related to Renewable Energy OECD, Paris

Overseas Development Council
1977 Energy for Developing Countries Report to Rockefeller foundation, Washington, D.C.

Pimentel, David
1978 Energy Needs, Uses, and Rescurces in the Food Systems of Developing Countries Cornell University Workshop report Ithaca N.Y.

Seward, T.A., et al
Rural Energy Center for Africa Using Solar, Wind and Biogas Energies. Brace Research Institute, McGill Univ. Quebec

Tanzania National Scientific Research Council
1978 Workshop on Solar Energy for the Villages of Tanzania, TNSRC, Dar es Salaam

Tendler, Judith
1979 Rural Electrification: Linkages and Justification - AID Program Evaluation paper No. 3. AID/PPC/E, Washington, D.C.

Walton, J.O. Jr., A.H. Roy and S.H. Bomar Jr.
1978 A State of the Arts Survey of Solar Powered Irrigation Pumps, Solar Cookery, and Wood Burning Stoves for Use in Sub-Sahara Africa for Al Dir'iyyah Institute, Washington, D.C. (Georgia Institute of Technology)

World Bank
1975 Rural Electrification, World Bank, Washington, D.C.