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RENEWABLE ENERGY TECHNOLOGIES IN KENYA:  
A PLACE IN THE SUN FOR THE PRIVATE SECTOR?

The Framework for a Market Study of  
Renewable Energy Technologies for Small-Scale  
Irrigation in Kenya

By

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WORKING PAPER NUMBER 402

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12 MARCH 1984

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ABSTRACT

The high expectations development planners have had for the widespread use of renewable energy technologies in developing countries have seldom been met. The failure of these technologies to provide their expected developmental benefits has been partly the result of an eagerness to demonstrate technologies that had not been adequately field-tested as well as the result of a certain short-sightedness about what these technologies could actually do. In the situations where these technologies have been employed with positive results, success has depended on the ability of the technologies to provide energy to meet individual end-uses, rather than on the willingness of the consumer to adapt end-uses so they would be capable of meeting the capacities of sometimes sophisticated technologies. In terms of energy substitution, the primary advantage of these technologies is that they can meet specific end-use energy demands, and not that they can have any substantial impact on a country's overall energy demand mix. Entrepreneurs in Kenya have successfully capitalized on the ability of small scale renewable energy technologies to meet specific end-use needs -- for instance, the need for domestic and industrial hot water, the need for irrigation, and the need for alternative cooking technologies.

Individual investment decisions favor renewable energy technologies when they can be guaranteed to provide for highly-valued end-uses, especially when conventional energy supplies or equivalently-scaled conventional energy conversion and utilization technologies are unreliable, unavailable, or are technically inappropriate. Public policy options that would have an effect on the extent to which these technologies are used should be determined on the basis of their potential developmental impacts, rather than on their energy substitution potential in the aggregate. This paper suggests a possible framework for a study of the market for renewable energy technologies in Kenya that could provide for a highly-valued end-use in a developmentally important sector, i.e. the markets for alternative energy technologies for small-scale irrigation.

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\* The author is a Visiting Research Associate at the Institute for Development Studies, University of Nairobi. This work is being supported with funds made available by the Fulbright program. The author wishes to express his appreciation to Dr. C.O. Okidi and to Dr. B. Okech for their helpful comments and criticisms of preliminary drafts.

## 1. Introduction

It has been widely argued that renewable energy technologies are especially appropriate for developing countries primarily because they can substitute for the use of imported conventional fuels, consequently conserving scarce foreign exchange while promoting energy independence. However, the experiences of developing countries with alternative energy technologies have not necessarily borne this argument out. The capital costs of implementing a renewable energy program on a scale large enough to have any major impact on a country's energy demand mix would be substantial and could not likely be paid for by the public sector -- in either developing or industrialized economies alike.

A free-market approach would suggest that if there is a place in the national economy for renewable energy technologies, markets for them would eventually be tapped by entrepreneurs who could manufacture and sell them. In fact, there has been an increasing interest on the part of governments in exploring ways in which the commercialization process could be facilitated, for instance, by stimulating the transition from early research and development stages to later investment, manufacture, and marketing stages. The ability and interest of the private sector in pursuing the commercialization of these technologies is a necessary prerequisite. But, most especially in developing economies, before governments take steps to stimulate the commercialization process, several critical and related issues need to be resolved: first, where would a "renewable energy" policy fall in the national policy context; second, where would the provision of the type of energy a renewable energy technology could provide have significant positive economic benefits or developmental impacts; and finally, in those sectors where the last criteria is met, what policy options could stimulate the private sector, for instance, to purchase and install these technologies.

This paper is an attempt to discuss some of the experiences developing countries have had in resolving these issues; to suggest that the Kenyan experience with renewables has been different because of individual entrepreneur's initiatives in developing commercially viable technologies; and to explore the potential for incorporating some of these renewable energy technologies into developmentally important sectors by relying on the private sector's investment potential.

II. Energy Policy Options in Kenya: the horns of a dilemma

It is perhaps redundant to repeat what most Kenyan policy analysts and planners know so well about the widening gap between the country's energy supply and demand.<sup>1</sup> To suggest that these are real disparities is perhaps misleading: energy in most forms is potentially available now, but its use is constrained by growing economic, environmental, and human costs. Conventional or commercial energy for instance, can be acquired but often at substantial prices in terms of foreign exchange, transport costs, and in terms of the investment capital required to increase thermal or hydroelectric generating capacity. Imported energy consumed 36% of export earnings in 1980, compared with 16% in 1978. In the case of the traditional sector, the most serious impact to date has not been any lack of energy; traditional fuels remain available, albeit often at a significant cost, for instance, sometimes in terms of human labor spent in collecting firewood and in terms of long-term environmental costs. Productive stocks of biomass resources are being rapidly depleted, nearly four times faster than their incremental rate of production.<sup>2</sup> The future use of these resources will clearly be constrained as a result.

Beyond the fact that the commercial and traditional sectors do consume huge quantities of fuel, there are few intersectoral similarities between their respective patterns of energy supply and demand. The uses as well as the types of energy used, for instance, are vastly different: fuelwood and other biomass resources are used primarily for cooking; petroleum and other conventional energy supplies are used for nearly every economically productive activity, providing energy for

<sup>1</sup> See for instance: UNDP/World Bank. Kenya: Issues and Options in the Energy Sector. Washington, D.C.: Joint UNDP/World Bank Energy Assessments Program, May, 1982;

Beijer Institute. Energy Development in Kenya: Problems and Opportunities. Stockholm: The Beijer Institute (The International Institute for Energy and Human Ecology of the Royal Swedish Academy of Sciences), 1982; and Lee Shipper, et al. Energy Conservation in Kenya's Modern Sector: Progress, Potential, and Problems. Washington, D.C.: Resources for the Future (unpublished Discussion Paper D-73i) May 1982.

<sup>2</sup> Western and J. Ssomakula. The Present and Future Patterns of Consumption and Production of Wood Energy in Kenya. Stockholm: The Beijer Institute, 1979.

Although the environmental impact of fuelwood consumption cannot be disputed, especially around urban areas, it should be noted that deforestation is more directly the result of other human encroachments, for instance, the demand for agricultural and settlement lands

transportation, for industry, for large-scale agriculture, and for a small sector of Kenya's residential population as well. Further, the costs that are incurred as a result of the consumption of conventional and traditional energy are substantially different. The economic costs of commercial energy consumption are quantifiable and may be paid off in the short term (although these costs have arguably resulted in the accumulation of large long-term foreign debts).<sup>1</sup> The costs of traditional energy consumption are not always obvious nor necessarily immediate. Except where biomass resources are commercially bought and sold, the most significant economic costs are often indirectly born over the long-term by the agricultural sector -- as watersheds become degraded and as Kenya's productive agricultural soils wash to the sea. Other social and environmental costs are less obvious over the short term. For instance, declining areas of the forest resource may have an impact on global temperature and climate over the long term; the loss of genetic diversity because of the degradation of tropical forests may be costly in human and economic terms. As sources of energy for the traditional sector become increasingly scarce, the provision of energy as a basic human need will become critically important if acceptable levels of human welfare are to be maintained.

Because of the differences between the basic natures of traditional and commercial types of energy and because of the attendant difficulties in generalizing the costs that must be incurred in order to maintain future supplies, appropriate public policy options and market interventions in the energy sector are sometimes obscure.<sup>2</sup> This problem has perhaps been best characterized by the difficulty some governments have had in incorporating the development of alternative renewable energy resources into their national economic plans.

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<sup>1</sup>Ricardo Marin and Marcelo Selowsky. Energy Prices, Substitution, and Optimal Borrowing in the Short Run: An Analysis of Adjustment in Oil-Importing Developing Countries. Washington, D.C.: World Bank (World Bank Staff Working Paper No. 466), 1981.

<sup>2</sup>See for instance the discussion in: Mohan Munasinghe. "Integrated National Energy Planning in Developing Countries," in Natural Resources Forum (4: 359 - 373), 1980.

Significantly, while most other types of development planning -- agricultural development, population planning, and health care delivery, for instance -- primarily affect specific sectors of a developing society, renewable energy planning can have neither this focus nor impact. Renewable energy technologies of multiple scales can be used in most sectors of the economy and it is intuitively difficult to identify renewable energy strategies per se because the question always arises, "Energy to do what?"<sup>3</sup>

This perception has not always been particularly clear. Especially in the mid-1970s, the high hopes and promises for the widespread use of small-and intermediate-scale renewable energy technologies in developing countries (prompted by the supply-sided notion that any renewable energy technology could be used in most any social and economic setting) remained, for the most part, unfulfilled.

There is good reason to suggest that the Kenyan experience has been different. This has been as much a result of the government's awareness of its own limitations as it has been the result of the real initiative the Kenyan private sector has shown in developing and marketing commercially viable renewable energy technologies.

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<sup>3</sup>The renewable energy technologies discussed here -- solar, wind, biomass, biogas, small hydro, etc. energy-based technologies -- primarily produce supplementary supplies of energy. Technologies that can reduce demands for energy, through conservation, have tremendous potential for reducing energy consumption in the aggregate -- both in the commercial and traditional sectors -- but they fall outside of the scope of this discussion. The issue of conservation is discussed at length in: Lee Shipper, et al. Energy Conservation in Kenya's Modern Sector: Progress, Potential, and Problems. Op. cit.

The policy implications of conservation are discussed in: Ministry of Energy, Republic of Kenya. Energy Conservation and Fuel Substitution Policy: Problem Statement. Nairobi: Ministry of Energy (mimeographed), 1982.

The former Minister for Energy, the Hon. Kebece M'Ubiijewe, noted the need for pragmatism during a speech to a gathering of representatives from Kenya's renewable energy private sector<sup>1</sup>:

"...(T)he private sector must take initiatives, and ... must accept some risks. It is not that we in government do not want to help you all we can. But no country ... can devote unlimited resources to the development of its new energy sources...

For many years, both the experts and the ordinary "wananchi" were accustomed to thinking of energy as a service provided exclusively by government. Governments organized and financed the great hydroelectric dams; governments undertook to distribute electricity to the people, and in recent years to ensure that supplies of petrol and fuel oil were made available. But the new sources of energy break this mould. The erection of a windmill, or the installation of a solar water heater, can be a very small project indeed. We in government do not intend to identify and supervise all of the many small projects that are needed. That is (the private sector's) task. We will assist the private sector. We will listen to reasonable requests, and we will consider major changes in policy, if these are needed. But the hard work of bringing renewable energy to the people -- this is the private sector's job as well as ours."

This combination of an awareness that difficult economic times have shifted public priorities in the energy sector, as well as an awareness that considerable private resources and talents could help to fill in some of the resulting gaps, has been the exception in the renewable energy area, rather than the rule.

III. Using Renewable Energy Technologies in Developing Countries:  
the challenge of matching technologies with end - uses

Critics of conventional energy strategies have vocally argued for the development of small-scale and renewable alternatives to the existing commercial energy supply structure, especially because

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<sup>1</sup>From a speech opening the Workshop on Opportunities for Investment ... in Energy Conservation and Renewable Energy Technologies and Projects in Kenya, Nairobi, 15 June 1983.



of the sharp increases in the price of petroleum of over a decade ago.<sup>2</sup> It was suggested that these "appropriate" or "intermediate" technologies<sup>3</sup> would have a comparative advantage over conventional energy sources in developing economies primarily because:

- 1) By reducing the consumption of conventional energy, renewable energy technologies would conserve scarce foreign exchange that would otherwise be spent on imported fuels. They would also contribute to making a country energy independent;
- 2) Although few renewable energy technologies are economically competitive where conventional energy supplies are easily available, they become much more so in remote areas. Even if renewable energy technologies are not currently economically competitive, projected rises in the price of conventional energy, as well as projected declines in the cost of renewable energy technologies, would make them so in the near future;
- 3) Other recurrent costs, such as maintenance costs, would be lower for renewable energy technologies than for conventional energy technologies of an equivalent scale and
- 4) Other benefits would result because the environmental impact of utilizing alternative energy technologies (not dependent on biomass resources) would be less than the impact of producing energy with fossil fuels. Further, the industrial production of renewable energy technologies could provide employment when they could be manufactured locally.

<sup>2</sup> See especially: Amory Lovins. Soft Energy Paths: Toward a Durable Peace. Cambridge: Ballinger Publishing Co., 1977. Lovins suggests that these technologies would be most compatible in societies structured in a decentralized way, that avoid "high" technology and that give lower priority to material consumption.

<sup>3</sup> Many renewable energy technologies are more technically sophisticated than the definition of "intermediate" technologies would allow. Schumacher suggested that (unlike many available renewable energy technologies) intermediate technologies should be relatively inexpensive, should be fairly simple and understandable and consequently easily maintained, should be made from local materials, and should require a degree of labor intensity during construction not afforded by the construction of conventional technologies. See: E.F. Schumacher. "Social and Economic Problems Calling for the Development of Intermediate Technology," in Proceedings of the UNESCO Conference on the Application of Science and Technology to the Development of Latin America. Santiago: UNESCO/U.N. Economic Commission for Latin America, 1965.

These arguments have been thoroughly woven into the fabric of renewable energy programs and literature and have been widely used to advocate their development, for instance in the Brandt Commission's Report,<sup>1</sup> in the Commission's follow-up study,<sup>2</sup> and most visibly at the 1981 United Nations Conference on New and Renewable Sources of Energy.<sup>3</sup>

But, for a variety of reasons, and despite substantial investments in them, alternative energy technologies have seldom lived up to these high expectations. Development planners, for the most part, assumed the technologies were well in hand and that all that had to be done was given to them, like a new car, a few test drives, and a prime spot in the showroom, before they would be widely accepted. Many renewable energy activities in developing countries were demonstrations that were intended to link early research and development stages with later investment and commercialization stages.<sup>4</sup> Unfortunately, much confusion was sown by the premature demonstration of technologies that were in fact being field-tested. False expectations have often been raised, and a certain cynicism has been the result in many quarters.

Technically complex renewable energy projects have often been designed with little consideration given to their economic or social appropriateness. They have, rather, been intended simply to test untried technologies. In Senegal, for instance, the French firm SOFRETES engineered, built, and installed a 25kW solar thermal electric generating facility (with French aid) in Diakhao, a small village of 500 inhabitants about 150km southeast of Dakar. A solar array, half the size of a football field, gathers heat and transports it to a thermoelectric conversion device that delivers 9kW per hour

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<sup>1</sup>Brandt Commission. North-South: A Program for Survival. Cambridge: MIT Press, 1980.

<sup>2</sup>Brandt Commission. Common Crisis: North-South -- Cooperation for World Recovery. Cambridge: MIT Press, 1983.

<sup>3</sup>See: U.N. Conference on New and Renewable Sources of Energy. Nairobi Programme of Action. 1981.

<sup>4</sup>Demonstration projects differ from research and development pilot projects because the technologies involved have significant potential for market development and for industrial scale production. Demonstrated technologies may still not necessarily be ready for market development because their inherent risks are considered by entrepreneurs to be too high.

continuously (using a heat storage tank at night or in cloudy weather). Designed to replace small diesel generating units which had previously provided electricity for the village, the solar unit was totally inappropriate for local conditions. Operating costs have remained high because of the necessity of hiring a French engineer to keep the unit running.<sup>1,2.</sup>

The fishing village of Las Barrancas (population 150) in Baja California, Mexico was "solarized" at a cost of \$40.6 Million, largely provided by German development assistance. A group of German companies including Dornier, AEG-Telefunken, Linde, and MBB participated in this project to design and install a 100 kW solar thermal power plant, a photovoltaic powered deep freeze, a solar desalination facility, and a photovoltaic-powered communications link. After considerable delay, the systems were completed and are working, but many villagers have had to radically change their lifestyles brought by the construction of the solar demonstrations. Essentially, the entire village had to be rebuilt to accommodate the complicated systems. The Las Barrancas project was undertaken with little thought as to whether it would be an appropriate replacement for the village's existing energy supply.<sup>3</sup> Projects such as the Diakhao and Las Barrancas activities have only tended to highlight the inappropriateness of testing unproven technologies in developing economies. Not all of these "technology-driven" types of activities have been failures, but outstanding successes have been uncommon.

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<sup>1</sup>Agence Francaise Pour La Maitrise de L'Energie. Project Memorandum. August 1981.

<sup>2</sup>For other interesting discussions about early experiences with renewable energy technologies in Africa, see also: Cheick Traore. "Development and Use of Solar Energy in Mali," in: Solar Energy: Proceedings of the UNESCO/WMO Symposium, 30 August - 3 September 1976:

Grace Hommings. Base-line Study for Socioeconomic Evaluation of Tangaya (Upper Volta) Solar Installation. Washington, D.C.: N.A.S.A./U.S.AID Cooperative Program, 1979.

<sup>3</sup>P.A. Dewees and R.T. Hf Hoffmann. Trends in Development Assistance for Renewable Energy. Washington, D.C.: International Institute for Environment and Development, August 1983.

While experience has shown that the technical complexity of a project which demonstrates new, unfamiliar, or inadequately tested technologies, more often than not contributes to its eventual failure, the inability of such projects to live up to developmentalists' expectations is more closely linked to local demand and acceptance, rather than on the basis of its alleged intrinsic merits.<sup>1</sup> As some observers have warned, project failure may result when a demonstration "is expected to convince people that an action is in their best interests and should be given top priority."<sup>2</sup>

Not surprisingly, the same conclusions can be drawn from demonstration-oriented development activities outside of the energy sphere. For instance, the Kenyan Special Rural Development Programme, started in the early 1970's, was intended to coordinate development activities in 8 administrative divisions in "high potential" areas as an experiment in project demonstration and replication. While the programme had a few limited successes in the target areas, ultimately, they could not be replicated in other areas, especially in low potential zones.<sup>3</sup> The example helps to emphasize that simply because a project is a good idea and may have worked somewhere else doesn't mean the experience can be replicated in all other settings.

New approaches toward incorporating small and intermediate-scale renewable energy technologies in situations where they might be most appropriate have been developing because of a growing perception of the need to identify the energy users' specific energy related needs before making energy producing technologies available. End uses, some observers argue, should dictate the most appropriate technologies to be used or adapted; end-use needs should not have to be adapted to meet the capacities of the preferred technologies. End-use energy

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<sup>1</sup>The argument against technical sophistication in complex projects does not necessarily hold with specific technologies. Photovoltaics, for instance, are technically sophisticated, but beyond the fact that they produce electricity, there is no need that the technology by itself must be understood for it to be useful.

<sup>2</sup>C. Toth and J.T. Cotter. "Learning from Failure," in: International Development Review Focus. (3:27-31), 1978.

<sup>3</sup>— Second Overall Evaluation of the Special Rural Development Programme. Nairobi: Institute for Development Studies (Occasional Paper Number 12), 1975.

needs are most easily identified in small-scale and discrete activities (i.e. shaft power is needed to operate agro-processing equipment). They become obscured when large-scale economic demands or activities require energy supplies that can be centrally produced and accessed, and that can be converted to meet a wide variety of demands (such as the demands that can be met by grid-provided electricity or by petroleum-based fuels).

Especially for small-scale renewable energy activities, if the demand for an energy supply of a certain form has had to be created, the technology rather than the end-use has become the focus of the effort. An extensive biogas program in Latin America (Supported by the Latin America energy agency, OLADE) developed several biogas generator designs. Few of the 65 generators that were installed as part of the project are currently operating. Reportedly, in rural areas where the generators were installed, the demand for biogas could not be created because fuelwood was the most socially and economically preferred fuel.<sup>1</sup> (It should be emphasized that the biogas option is still a very real one, as quite successful and widespread activities have been mounted in other social and economic settings, particularly in India, China, Thailand, and in Philippines.<sup>2</sup>)

Although the use of both large and small-scale renewable energy technologies could arguably have an impact on the commercial energy demand structure of the developing economies, their impact on energy consumption in the traditional sector will most likely remain negligible, well into the next century. There are few renewable energy technologies that are able to economically meet the end-uses which are currently met by fuelwood and other biomass energy resources.

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Dr. Norman Brown, personal communication, November 1982.

<sup>2</sup> See for instance, Andrew Barnett, et al, Biogas Technology in the Third World: A Multidisciplinary Review. Ottawa: International Development Research Center, 1978.

Improvements in the conversion efficiency of cooking stoves hold good potential because such improvements can be made quite cheaply.<sup>3</sup>

But there are no renewable energy technologies per se that can provide the type of energy provided by fuelwood and that can be afforded by a significant proportion of the rural poor. Considering that between 50% and 95% of the energy required by developing economies is provided by fuelwood, it is open to some question whether renewable energy strategies should be pursued at all in developing countries because the costs of not focusing on the long term energy needs of the traditional sector would be much greater. There is, however, a middle ground. Renewable energy technologies are appropriate where the commercial infrastructure is such that renewable energy

can be tapped on a large scale (by hydroelectric generating facilities, for instance) and where available small-scale technologies can be economically adapted and utilized to meet specific end-use needs. To some extent, this middle ground has been successfully exploited in Kenya.

#### IV. Exploring the Markets for New Energy Technologies in Kenya

Especially since independence, renewable energy has played a significant role in providing Kenya with conventional energy. Between 1978 and 1981, hydroelectric generating stations provided between 60% and 83% of the electricity generated in Kenya. Studies indicate that, by the end of the century, 560 MW of installed hydroelectric capacity could be added to the current 350 MW. Geothermal electric generation (although arguably a "renewable" energy) accounted for 2% of total electricity production in 1981 (although this figure has risen since then) from two 15 MW generating Units. Total geothermal generating potential is conservatively estimated at 170 MW. And finally, a relatively minor amount of ethanol is being distilled from sugar cane to supplement supplies of gasoline. Together, hydroelectricity, geothermal

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<sup>3</sup> See for instance: Volunteers in Technical Assistance, Woodstove Design Manual. Mt. Rainier, WA.: VITA, 1979. and

Gerald Foley and Geoffrey Barnard, Improved Cooking Stoves in Developing Countries London: Earthscan, 1983.

electricity, and ethanol account for around 20% of total conventional energy production.<sup>1</sup>

The characteristics of the large-scale renewable energy industry in Kenya are very similar to the characteristics of the commercial energy industry as a whole. The decision of a utility or an industry to invest in the future development of these resources is based primarily upon the projected demand for energy over a given time horizon, and on the relative availability and economic "exploitability" of these resources when compared with other conventional fuels. The technologies involved are relatively well understood, and as a result, technical constraints to developing these resources are fairly minor. Within the next 20 years or so, the market for the large-scale production of hydro- and geothermal electricity will be limited by the extent of the exploitable supply; it is anticipated that these resources will be exploited to the maximum extent possible with large-scale conventional technologies by the mid-1990's.<sup>2</sup>

Small-scale renewable energy technologies in use in Kenya have few, if any, similarities with large-scale technologies other than that they convert common sources of renewable energy into more useful forms. Solar, wind, water, and biomass resources are in abundance in Kenya (although less so for the latter because of a dependence on them by the traditional sector). In theory, these resources could be exploited on a large scale by "alternative" technologies. In reality, the extent to which they could be exploited is dependent on site-specific demand and supply characteristics such as the demand for hot water or irrigation facilities on the one hand and on the other, site specific energy supplies in the form of, for instance, solar radiation or wind. Finally, the extent to which these resources are exploited is mostly dependent on whether or not conversion technologies of the appropriate scale are available in Kenya, and on whether or not individual consumers are interested and willing to make the substantial investments in the

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<sup>1</sup>UNDP/World Bank. Kenya: Issues and Options in the Energy Sector. Op. Cit.

<sup>2</sup>Mike Jones, personal communication, February, 1984.

purchases of these technologies. Obviously enough, these last two points are in fact the most critical: without the appropriate conversion and utilization technologies, renewable energy can't be tapped on a small scale at all (or at least not with any efficiency); without the markets for these technologies, no producer would be willing to manufacture them.

To a certain extent, the first point is moot. There are perhaps as many as two dozen small enterprises that are locally manufacturing (or assembling) and marketing a variety of small-scale renewable energy technologies. Among developing countries, Kenya is almost unique in this respect.<sup>1</sup> These technologies include windmills for pumping water, solar water heaters, biogas production units, biomass pyrolysis devices, and photovoltaic-powered water pumps.<sup>2</sup>

The second point is less evident. It is perhaps a non-sequiter to suggest, as we have, that because there are local manufacturers of renewable energy technologies, there must be markets for them, - or that because there are markets for renewable energy technologies, local manufacturers are producing them. In fact, like most entrepreneurs, local manufacturers have sought to create markets for their products, in this case, by producing for a share of the market that would otherwise have been met by the producers of conventional energy conversion and utilization technologies of an equivalent scale. This approach has required that manufacturers produce technologies capable of meeting specific end use needs. Without exception, this fact has predicated market entry.

Because the producers of alternative energy technologies are manufacturing devices to perform the otherwise equivalent functions of conventional small-scale energy conversion and utilization technologies, the consumer has two primary considerations in making an investment

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<sup>1</sup>Other developing economies which support small alternative energy industries include South Korea, the Philippines, Jamaica, Colombia, Pakistan, and India.

<sup>2</sup>There is a notable absence of manufacturers (or importers) of small-hydroelectric technologies. This is perplexing in view of abundant water resources, for instance, in Western Kenya. Some studies of the small-hydro potential in Kenya have suggested that these types of technologies are only economic where they can be installed at least 45 km from the main grid. But experience, for instance in Pakistan and Nepal, has shown that low-cost devices can be manufactured at a cost of US\$ 350 to 500 per kw (1981 prices). Low-cost units such as these could be economically installed much closer to the main grid.



decision. The first is whether or not the alternative energy technology can economically provide for the same end-use as the conventional technology. This is usually thought to be a question of the economics of energy substitution; in reality, the economic question is much more complicated (and is addressed in the following section). Beyond the question of the economics of the technology under consideration, is the question of risk. Because conventional energy technologies have a track record, the consumer is able to incorporate his own risk assessment into the economic analysis. He can determine, for instance, how often a crop failure is likely to result if his diesel irrigation pump breaks down or if he is unable to get fuel. He can decide, consequently, whether or not he is willing to take a few risks. Because renewable energy technologies are relatively new and have no real track record to speak of, because of the often large initial capital requirements, and because of the often rapid pace of technological change, even with new technologies, investors in alternative technologies are often risk takers.<sup>1</sup>

Risk aversion has always contributed to the slowness (or failure) of societies and individuals to accept new technologies. Mureithi suggests that inappropriate technologies are in evidence, regardless of factor prices, because of what he calls "technological stickiness" — the propensity to rely on extraeconomic considerations like risk avoidance, an appeal to "modernity", and established procedures and familiar techniques.<sup>2</sup> In the case of renewable energy technologies, the risk, however, is not the consumer's alone.

Demonstrations of field-tested or otherwise proven technologies are often used to popularize technologies as well as to reduce the consumer's perception of risk. Earlier, we suggested that demonstration projects in the energy sector have been intended to link early research and development stages with later investment and commercialization stages. Many of these activities have been supported either by

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<sup>1</sup>The record on this point is clear. The largest group of investors in the most expensive renewable energy technologies available in Kenya have been large land-holders and commercial concerns, public sector, charitable, and development assistance agencies.

<sup>2</sup>Leopold P. Mureithi. Project Identification and Technology Choice with Perspectives from Kenya. Nairobi: University of Nairobi, Economics Department (mimeographed, undated). Cf. Barhael Kaplinsky. Inappropriate Products and Techniques. Nairobi: Institute for Development Studies (Working Paper No. 335).

entrepreneurs interested in marketing particular technologies or by public sector agencies interested in facilitating the investment process. For the most part, they have been the most willing (or able) to finance the purchases of technologies at the risk of being unable to establish the commercialization link.

When there are no public agencies willing to finance demonstration projects of any significant scale, the entrepreneur lacking the resources to mount his own demonstration effort, may end up using his first private purchases as demonstrations. The risk here is twofold: on the part of the consumer who is purchasing a technology that may not have been adequately field-tested, and on the part of the entrepreneur who, by selling technologies that may have heavy maintenance demands because all the "bugs" hadn't been worked out, may discourage future buyers if he is unable to keep his devices working.

The record in Kenya has been mixed. Especially with intermediate-scale technologies such as windmills, entrepreneurs have relied for the most part on both public and private purchases to finance demonstration activities. (In recent years, Kenyan-produced windmills have perhaps been more readily commercialized than other less familiar technologies because of a long history of use in Kenya. Reportedly, between the turn of the century and the early 1960s, at least a hundred windmills had been imported, although the exact number is not known.<sup>1</sup>) Around the time of the U.N. Renewable Energy Conference in Nairobi in 1981, when renewables were at a peak of popularity,

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<sup>1</sup>W. E. van Lierop and L. R. van Veldhuizen. Wind Energy Development in Kenya. Amersfoort (The Netherlands): Steering Committee on Wind Energy in Developing Countries (Volume 1: Past and Present Wind Energy Activities ), November 1982.

there were over 20 firms in Kenya importing or manufacturing solar water heaters. But within a year, more than a dozen firms had disappeared from the scene, partly because of heavy competition in a limited market and partly because of the high costs that were being incurred by the industry to maintain poorly constructed heaters. At a time when the industry needed to convince consumers of the solar potential, to a certain extent, solar water heaters acquired a reputation for being inefficient and unreliable. Since then, the remaining manufacturers retrenched; those that have been able to make it through tough economic times are producing heaters of high quality while retaining (or expanding) their shares of the market. These early experiences notwithstanding, there is apparently a growing awareness of the potential some of these technologies hold when used in the right setting and depending also on the investment criteria one chooses to rely upon. Other viable approaches can be taken without extensive demonstration efforts. Professional organizations, for instance, may be another mechanism for increasing an awareness about renewable energy technologies, although this avenue has not been used to its greatest advantage.<sup>2</sup>

V. Beyond Risk: Assessing the Value of an Investment in a Renewable Energy Technology.

As we pointed out earlier, because the renewable energy technologies that are being sold in Kenya are primarily being produced to take a share of the market that would otherwise be met by the producers of equivalently-scaled conventional energy conversion and utilization technologies, it is usually thought that their competitiveness is dependent on the economics of energy substitution. Indeed, much of the literature written to justify the viability of renewable energy technologies in developing countries is dominated by this argument.

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<sup>1</sup> D.G. Simpson and H.W. Lane. The Opportunities and Challenges of Starting a joint venture in Kenya: the case of PETRO-SUN, Kenya Ltd. (mimeographed), 1983.

<sup>2</sup> Silas M. Ita, Director/Chief Executive Kenya Association of Manufacturers, from an address to the Workshop on Opportunities for Investment in Energy Conservation and Renewable Energy Technologies and Projects in Kenya, 15 June 1983.

But there is reason to think that the argument is particularly short-sighted. Especially when comparing small-scale energy conversion and utilization technologies, non-priced values and non-conventional costs and benefits may obscure the real net value of an investment.<sup>1</sup>

From the public sector's perspective, energy-substitution and economic analyses of renewable energy technologies cannot, by themselves, produce all the necessary information for determining policy options to affect future development. Nor can the manufacture of these technologies produce enough information for the same end. Using either approach would underestimate the inter-relationships of new types of energy production with other factors of production, particularly with natural resource availability and with the availability (or potential availability) of foreign exchange must be carefully assessed before implementing policy options that might promote (or hinder) the renewable energy industry. This issue becomes critically important when foreign exchange restrictions have boosted the shadow prices of imports far above nominal monetary prices. Except for the most rudimentary energy technologies, a dependence on foreign sources of material and technologies is commonly involved.<sup>2</sup> There is a need, then, to assess the potentially high opportunity costs of diverting scarce foreign exchange from other priority sectors. It could be the case that the opportunity costs of spending foreign exchange on imported fuels instead, could be relatively low simply because the oil-refining industry's economies of scale may be much more favorable. The point has not been lost on the energy industry in Kenya. A recent analysis of the market for solar hot water heaters in Kenya, supported in part by a major local producer, suggested that Kenya's balance of payments difficulties will make it increasingly difficult to consider utilizing solar collectors which have a low

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<sup>1</sup>See also the discussion in: Ramesh Bhatia. Energy and Rural Development: An Analytical Framework for Socio-Economic Assessment of Technological and Policy Alternatives. New Delhi: Institute of Economic Growth (mimeographed), 1980.

<sup>2</sup>Advisory Committee on Technology Innovation. Energy for Rural Development: Renewable Resources and Alternative Technologies for Developing Countries. Washington, D.C.: National Academy of Sciences, 1976.

"local content".<sup>1</sup>

Another point for policy-makers to consider is the aggregate non-energy impact of the production and use of alternative energy technologies on the development process as a whole. For instance, how many jobs are being created directly by the industry and indirectly in sectors where these technologies are being used? The Kenyan firm which produces the Kijito Windmill, Bobs Harries Engineering Ltd. (BHEL), employs around 40 people. Windmills like the Kijito are appropriate for small-scale irrigation projects of 5 to 50 ha.<sup>2</sup> The implied coefficient of employment for irrigation projects is estimated to be between .6 and 4 man years per hectare.<sup>3</sup> A dozen Kijitos irrigating a dozen twenty hectare plots could theoretically provide employment for between 144 and 960 people. In spite of this wide range in the employment potential, considering that between 200,000 and 500,000 ha. of marginal lands in Kenya could be made agriculturally productive under different irrigation schemes, the employment benefits that might accrue because of the widespread use of windmills could be substantial. However, the individual investment decision of whether or not to purchase a windmill would most likely be made independently of this aggregated employment potential.

If we were to look at the potential that alternative energy technologies hold for substituting for conventional fuels on the national scale, the results of such a glance would be disheartening. Kenya admittedly has an abundance of renewable energy resources that could be tapped, but the extent to which small-scale technologies could tap them and affect the nation's energy balance as a result is limited. For instance, Kenya receives an average of 5.5 kwh/m<sup>2</sup> per day in solar radiation because of its favourable equatorial location; the country as a whole receives over 3 million GWh in solar radiation per day. (Its annual electricity demand in 1982 was only .06% of the average total daily insolation.)<sup>4</sup> Yet even with this abundance of solar radiation,

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<sup>1</sup> Petro Sun, International. A National Solar Program for Kenya: Kenya Solar Utilities Program Feasibility Study. Ontario (Canada): Petro Sun/CIDA, 1984.

<sup>2</sup> W. E. van Lierop and L. B. van Veldhuizen. op cit.

<sup>3</sup> World Bank. Growth and Structural Change in Kenya: A Basic Economic Report (Annex II: Issues in Kenyan Agricultural Development). Washington, D.C.: World Bank Eastern Africa Regional Office, 1982.

<sup>4</sup> FIDIMI Consulting SpA. Energy Consultancy for the Ministry of Energy of Kenya. Rome: Centro Studi Energetici (CESSE), February 1982.

a recent study indicated that the installation of enough solar water heaters -- around 127,000 m<sup>2</sup> of collectors -- to meet Kenya's primary market demand<sup>5</sup> for hot water would displace only 8% of annual electricity requirements (in 1982).<sup>6</sup> A major effort at conservation could possibly save the same amount of electricity, perhaps at a much lower cost.

(The question is made somewhat more difficult to assess because of the fact that most hot water is heated during off-peak periods using specially metered "rioles" electricity supplies. Consequently, the widespread installation of solar water heaters would have little impact on the peak demand for electricity. It would merely reduce the off-peak load, and would have little impact on the need for increasing the system's installed generating capacity to meet peak demands).

A similar argument can be made against using renewable energy technologies to substitute for the use of conventional energy in the agricultural sector. The energy demands for irrigation, for instance, are minimal when compared with the national energy balance. The agricultural sector consumes about 8.6% of the fossil-based fuels used in Kenya, of which perhaps a fifth is used to fuel irrigation pumps. The agricultural sector accounts for 2.5% of total electricity demand, of which virtually all is used for irrigation.<sup>7</sup> Even if the energy used by the irrigation subsector could be totally provided by alternative energy technologies, the effect on the national energy demand structure would hardly be felt.

Although these arguments hold true in the aggregate, what about the individual consumer? Would the energy savings alone that would result from investing in a renewable energy technology be enough to convince a consumer to purchase such a technology? The answer is of

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<sup>5</sup>The primary market consists of those consumers who are using a variety of conventional or commercial fuels to heat water.

<sup>6</sup>Petro Sun, International op cit.

<sup>7</sup>1979 Consumption from Leo Shieger, et al. op. cit.

course dependent on the type and scale of the technology involved and on the end use to which it is applied. For instance, the energy-cost payback for a selection of solar hot water heating technologies in Kenya has been estimated to vary between 5 years 7 months (for commercial/institutional consumers of Tariff B1 electricity) and 14 years 5 months (for commercial/institutional users of fuel oil). The estimated payback for middle-income residential Tariff D electricity consumers is around 9 years.<sup>1</sup> From the hot water consumer's point of view, the investment may be a worthwhile one; the benefits may be enhanced under other assumptions of fuel costs, inflation, location, interest rates, etc. However, the case is not as clearcut for other technologies and end-uses. A 1981 study pointed out that energy costs represent less than 10% of the total net present cost for small-scale conventional water heating devices, and that consequently, fuel prices will influence a consumer's investment decision very little.<sup>2</sup> In a review of selected cases where renewable energy technologies had been installed in a variety of developing country settings, one writer suggested that, when compared with the costs of conventional technologies, none of the technologies reviewed showed any immediate promise or advantages for significant developmental applications.<sup>3</sup>

These decidedly pessimistic examples are not intended to undermine the rationale for using alternative energy technologies. Rather, they are simply intended to help to emphasize that the energy substitution argument is myopic. As we suggested earlier, from the public sector's perspective, economic and energy-substitution analyses cannot, by themselves, produce all the necessary information for determining public policy options to affect future development. The same holds true for individual consumer. These types of analyses may quite likely undervalue high-valued end uses for certain technologies. Perhaps the soundest

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<sup>1</sup> Petro Sun, International. op. cit.

<sup>2</sup> Robert Gordon, et al. The Economic Costs of Renewable Energy. Washington, D.C.: Development Sciences, Inc., 1981.

<sup>3</sup> David French. The Economics of Renewable Energy Systems for Developing Countries. Washington, D.C.: U.S. AID/al Dir'iyyah Institute, 1979.

argument for an investor to purchase an alternative energy technology is that it could provide a source of energy where other supplies are unavailable, unreliable, or are otherwise technically inappropriate. In any of these cases, while cost is an issue, it is often no longer central to the consumer's investment decision. These cases escape mention in the usual analyses primarily because they are difficult -- if not impossible -- to cost out. (In these cases, the price elasticity of demand for energy is low. The quantity of energy demanded will be fairly unresponsive to increases in price).

Consider for a moment the consumer who purchases a flashlight. On a cost per kilowatt basis, the decision to purchase the flashlight would be irresponsible because of its insatiable and expensive energy appetite. Given that two size AA long-life flashlight batteries (costing around 25/-) can power a half-watt flashlight bulb continuously for around 4 hours and 20 minutes, the cost is roughly 11,424/- per kilowatt hour. This compares with an off-peak cost of electricity available to a Kenyan utility customer of around 47K¢ per K kWh. Even photovoltaics, at a cost of over 100/- per peak watt would be a bargain when compared with the cost of flashlight batteries. So what would possess our consumer to choose his hand torch over plugging a bulb into a lamp socket or powering his light with photovoltaics? Obviously, he has no easy access to grid-connected electricity, and if he needs a flashlight in the first place, photovoltaics would be technically inappropriate. The example serves to emphasize that a highly valued end-use, energy availability, and technical appropriateness may help to justify an investment in any of several technologies.

In summary, the decision to develop policy options that will have an impact on the renewable energy industry in Kenya must be made primarily using criteria other than its energy-saving potential. These criteria might include issues such as:

- 1) The availability of foreign exchange. Can the country afford to support the development of technologies that have a low domestic content? What would be the relative opportunity costs to other developmentally important sectors if foreign exchange were diverted from them to support a renewable energy industry?



- 2) The impact on employment. What direct and indirect employment effects will the industry have. How labor intensive is the industry itself, and to what extent might the technologies involved have an impact on employment in other sectors?
- 3) The potential for alternative development. What would be the developmental impacts of using these technologies in specific command zones where conventional energy and/or conversion and utilization technologies are unavailable, unreliable, or are at a technical disadvantage? In these areas, would there be other potential benefits such as an increase in health standards or better nutrition.
- 4) Income and distributive effects. Is the distribution of income in the productive sectors that could be using alternative energy technologies an economic, political, or social issue? What distributive effects might be felt if these technologies were used on a significant scale? What mechanism could be established to make the financial resources available to a larger number of potential investors in alternative energy technologies? To what extent would public ownership of the technologies under consideration alter and improve the distributive effects (or even have an effect on the useful life of the technology)?

Although the costs of the energy displaced by the use of alternative energy technologies would play a part in an individual consumer's investment decision (an admittedly substantial part if these costs were large), other criteria will assume an equal or greater importance. For instance<sup>1</sup>:

- 1) The availability of energy supplies. Does the existing infra-structure guarantee that energy supplies will be available for conventional energy technologies? Do site-specific characteristics guarantee renewable energy inputs will be sufficient to produce the required output?
- 2) Reliability of the technology. What level of maintenance will be required over the life of the technology? Who will be needed to provide the maintenance?
- 3) Technical appropriateness. Do any of the technologies under consideration have any technical advantages? For instance, are the technologies available in the appropriate scale to meet projected demands?

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<sup>1</sup> Cf. J.B. Margolin and M.R. Misch. Psycho-Economic Factors Affecting the Decision Making of Consumers and the Technology Delivery System. Washington, D.C.: U.S. Department of Energy (Solar Energy Incentives Analysis Project), 1978.

- 4) Highly-valued end-uses. Will the technologies under consideration provide energy to meet specific and highly-valued (either economically or socially) end-uses?
- 5) Risk assessment. Do the technologies under consideration have a proven track record? How risk averse is the investor?
- 6) Is investment capital available?

As was implied earlier, the fact that local manufacturers are producing and marketing renewable energy technologies indicates that there is at least a potential market in Kenya for these devices; continued sales have borne the notion out. The impression is shared by others as well. A recent "Renewable Energy Video Catalog Exhibition" in Nairobi, sponsored by the American Embassy and the U.S. Department of Commerce was geared toward stimulating interest among Kenyan investors in "one time sales, joint ventures, licensing arrangements, (and) technology transfers"<sup>2</sup> of American renewable energy technologies. But, other than a general perception that there are markets in Kenya for these technologies, manufacturers and potential investors in the industry have only a limited view of the market's size and of what measures could be taken to more effectively increase their market shares.<sup>1</sup>

#### VI. Assessing the Markets for Renewable Energy Technologies in Kenya

So the obvious question that follows is --- What are the size of these markets? From the manufacturer's point of view, the question helps to define a marketing strategy. From the potential consumer's view point, the question is significant, especially in terms of complementary and risk reducing effects. A market study would help to contribute to the consumer's investment decision by identifying the types of end-use specific technologies available and the scale of potential uses for these technologies. If there are a large number of devices installed in the field (or that may potentially be installed), the consumer would identify benefits resulting from the eventual diffusion

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<sup>2</sup>U.S. Ambassador Gerald E. Thomas, letter welcoming guests to the Renewable Energy Video Catalog Exhibition at the American Cultural Center, Nairobi --February 28 and 29, 1984.

<sup>1</sup>Two recent studies have been the exceptions. These studies assessed the markets for solar water heaters (see: Petro Sun, International, op cit) and the markets for water pumping windmills (see: W.E. van Lierop and van Veldhuizen. op cit.)

of technical and maintenance know-how (the "demonstration effect".<sup>2</sup>) There would be an associated reduction in the consumer's perception of risk if he knew whether or not he would be one of many -- or just a few -- potential investors in a specific technology. And finally, from the public sector's perspective (especially for large-scale publicly funded activities) there would be similar complementary and risk reducing benefits resulting from a comprehensive market study. Perhaps more importantly, a market study would help to identify the potential for significant positive developmental impacts that might result because of the widespread adoption of specific technologies. This last point is perhaps the most important for developing policy approaches toward renewable energy technology development in the national context, or perhaps at the regional or local level (for instance through Regional Development Authorities). It would help to clarify, for instance, the approaches that could be taken to stimulate the industry by targeting publicly supported awareness building efforts at markets of greatest potential. It would also help to identify the industry's primary constraints, and would suggest policy options for alleviating these constraints.

In order to more finely focus an effort at assessing the markets for renewable energy technologies in Kenya, there would be several criteria that should first be met. First, the markets for technologies to meet a specific end-use should be addressed, rather than the markets for alternative energy technologies *per se*. Secondly, the end-use (and not necessarily the technologies) should be developmentally useful, that is to say, there should be significant positive developmental impacts that would result if these end-uses could be provided for on any scale. These criteria would help both to eliminate a technical bias in the study for or against any specific technology (or group of technologies) and would help to focus on the potential that technologies may have for meeting end-use needs rather than on the potential the same technologies would have for displacing conventional fuels in the aggregate.

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<sup>2</sup> Peter Thompson, Showing off the Sun: An Appraisal of Renewable Energy Demonstration Projects. Washington, D.C.: International Institute for Environment and Development, 1983.

Technologies that could pump water for irrigation purposes are a case in point. Conventional irrigation technologies that are currently being marketed in Kenya include diesel and gasoline powered pumps as well as electric pumps powered either by remote generators or by electricity provided by the grid. Alternative energy irrigation technologies currently being marketed in Kenya include windmills, photovoltaic-powered water pumps, and biomass gasifier-powered pumps.

Without question, the provision of irrigation facilities could have substantial positive developmental benefits. The ability of the irrigation subsector to contribute to growth in agricultural production over the next several decades will have to be tapped. In the 23 years between 1977 and 2000, Kenya will have to increase agricultural production by 2.2 times simply to keep production constant in per capita terms. Because of a rapidly growing labor force, and because of the limited capacity of the nonagricultural sector to increase its rate of job production, the agricultural sector will have to absorb much of the burden. Some estimates have suggested that even a 4% annual growth in the rate of nonagricultural job production will force the agricultural sector to absorb more than 5 times its present number of workers by the year 2000.<sup>1</sup> The current National Development Plan envisages an average annual rate of growth in agricultural output between the years 1980 to 1995 of around 5%.<sup>2</sup> This would be less than the average annual growth in the nation's Gross Domestic Product for the 1970 - 1980 decade, but would be greater than the rate of growth in agricultural output for the same period. In every way this would be a formidable objective.

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<sup>1</sup>This discussion benefited greatly from: World Bank. Growth and Structural Change in Kenya (Annex II: Issues in Kenyan Agricultural Development). op cit.

<sup>2</sup>Cited in FIDIMI Consulting SpA. op cit.

Although the issues are not terribly clearcut (nor adequately addressed in this brief discussion), irrigation could help to increase the area of land under production, thus helping to increase agricultural productivity and the rate of sectoral job creation. Conventional irrigation schemes, however, have been costly and technical problems have plagued some efforts. An estimated cost for the irrigation of 500,000 ha of marginal lands has been KSh 600 million (US \$4.3 billion in constant 1979 prices) or KSh 1200 per hectare. Although the cost per job created would be much less (as much as 90% less under the most favourable of assumptions) than the cost per job created in the manufacturing sector, large-scale irrigation costs could absorb as much as 60% of total projected investment funds available for agriculture between 1981 and the year 2000. In view of the uncertainties about cost and the amount of land potentially irrigable (estimated to be between 200,000 and 500,000 ha) the Government's strategy for irrigation seems appropriate: to proceed cautiously with presently planned large-scale irrigation projects, to make no new large-scale commitments, and to promote private and small-scale irrigation development.

Especially in view of this last point, a study of the market potential for renewable energy small-scale irrigation technologies vis-a-vis conventional technologies, in Kenya would be both timely and appropriate. The author intends to undertake such a study over the next eight months.

The objectives of this study would be to:

- assess the potential of locally manufactured or assembled wind, photovoltaic, and biomass gasifier technologies for small-scale irrigation;
- assess these technologies with respect to conventional small-scale irrigation options; and to
- identify possible policy approaches, where appropriate, for stimulating consumer demand, and consequent industrial production.

The study would be carried out to address the following specific questions:

1. State of technology development

Assess the state of wind, photovoltaic, and gasifier irrigation technologies in Kenya, including such aspects as technical sophistication, performance characteristics, maintenance demands, production characteristics (state of the industry), and the markets that have been addressed thus far.

2. The availability of renewable energy resources

Within Kenya's geographic and climatic setting, what is the availability of wind and solar resources? What levels of competition with the traditional sector could be expected for biomass resources? What seasonal fluctuations in insolation and in the wind regime could be expected?

3. Structure of water supply and irrigation demand

What is the availability of groundwater. What is the pattern of precipitation, and what are the reference levels of evapo-transpiration. What is the size of the primary market -- the market for irrigation technologies for areas currently not under agricultural production. What is the size of the secondary markets -- the markets for irrigation technologies that could potentially replace existing conventional technologies, or that could supplement water supplies where agriculture is currently rainfed, etc.

4. What levels of infrastructure or lack of infrastructure may affect the viability of alternative technologies.

What areas are accessible by road? What are the transport costs for conventional energy? What are distance-dependent maintenance costs? What areas are close to the main grids.

5. Extra-economic considerations by the consumer

Based on the operating records thus far, what have been the primary risks to investors in alternative irrigation technologies? What has been the rate of employment generation? Has conventional fuel substitution affected these technologies' viabilities? To what extent have consumers installed technologies within access of conventional sources of energy.

6. What is the Net Present Cost of the technologies (or technology combinations) under consideration?

How sensitive are these costs to fuel price, rates of interest, maintenance costs, discount rates?

7. What policy options would be appropriate with regard to these technologies and the irrigation sub-sector.

Tax incentives/disincentives. Import protection. Direct subsidies. Financing arrangements, Comprehensive demonstration efforts, etc.

The study will rely where appropriate and, in some cases heavily, upon information generated as a result of other analyses. For instance, the SWD Report on Wind Energy Development in Kenya contains substantial information about wind regimes, groundwater characteristics, and costs. When possible, such information will be updated.

A subsequent working paper will describe refinements in the study outline and will discuss the work in progress. A final paper will present the findings of the study at the end of the eight month study period.