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AGENCY FOR INTERNATIONAL DEVELOPMENT

PROJECT PAPER FACESHEET

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PP

2. DOCUMENT CODE: 3

3. COUNTRY/ENTITY: Mali

4. DOCUMENT REVISION NUMBER:

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9. ESTIMATED DATE OF OBLIGATION: A. INITIAL FY 78; B. QUARTER 4 (Enter 1, 2, 3, or 4); C. FINAL FY 81

10. ESTIMATED COSTS ($000 OR EQUIVALENT $1 =)

A. FUNDING SOURCE	FIRST FY B. FX	FIRST FY C. L/C	FIRST FY D. TOTAL	LIFE OF PROJECT E. FX	LIFE OF PROJECT F. L/C	LIFE OF PROJECT G. TOTAL
AID APPROPRIATED TOTAL	1,031	469	1,500	2,031	1,883	3,914
(GRANT)	(1,031)	(469)	(1,500)	(2,031)	(1,883)	(3,914)
(LOAN)	( )	( )	( )	( )	( )	( )
OTHER U.S. 1. Peace Corps		44	44		220	220
OTHER U.S. 2.						
HOST COUNTRY		852			1,184	1,184
OTHER DONOR(S)						
TOTALS		1,365				5,318

11. PROPOSED BUDGET APPROPRIATED FUNDS ($000)

A. APPROPRIATION	B. PRIMARY PURPOSE CODE	PRIMARY TECH. CODE C. GRANT	PRIMARY TECH. CODE D. LOAN	E. 1ST FY F. GRANT	E. 1ST FY G. LOAN	H. 2ND FY I. GRANT	H. 2ND FY J. LOAN	K. 3RD FY L. GRANT	K. 3RD FY M. LOAN
(1) SH	740	873		1,500		800		800	
(2)									
(3)									
(4)									
TOTALS				1,500		800		800	

A. APPROPRIATION	N. 4TH FY O. GRANT	N. 4TH FY P. LOAN	Q. 5TH FY R. GRANT	Q. 5TH FY S. LOAN	LIFE OF PROJECT T. GRANT	LIFE OF PROJECT U. LOAN
(1) SH	814				3,914	
(2)						
(3)						
(4)						
TOTALS	814				3,914	

12. IN-DEPTH EVALUATION SCHEDULED: MM 06 YY 80

13. DATA CHANGE INDICATOR. WERE CHANGES MADE IN THE PID FACESHEET DATA, BLOCKS 12, 13, 14, OR 15 OR IN PRP FACESHEET DATA, BLOCK 12? IF YES, ATTACH CHANGED PID FACESHEET.

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14. ORIGINATING OFFICE CLEARANCE

SIGNATURE: Ronald D. Levin

TITLE: Mission Director

DATE SIGNED: MM 06 DD 22 YY 78

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MALI RENEWABLE ENERGY

PROJECT PAPER

JUNE 1978

MALI RENEWABLE ENERGY PROJECT PAPER

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INTRODUCTION

The development of this project began with a mission to Mali by the Overseas Development Council under a grant from USAID in November and December 1977. The Project Identification Document was drafted jointly by the ODC and USAID/Mali. Reviewed on March 20, 1978, the PID was approved by telegram on May 1, 1978.

The Center for Research on Economic Development of the University of Michigan was retained under work order number 15 of Indefinite Quantity Contract number AID/afr-C-1143 to prepare the Project Paper.

The PP team, which visited Mali from May 2 to June 7, 1978, consisted of:

Peter B. Hammond, cultural anthropologist
Clarence F. Kooi, renewable energy scientist
J. Clark Spooner, general engineer (REDSO/WA)
Charles Steedman, team leader
Youssouf Sylla, economist

In the final week of the team's stay in Mali, John D. Blumgart of AFR/DR assisted the mission in completing its work and drafting the Project Paper.

PROJECT DESCRIPTION*

The two basic purposes of this project are (a) to improve the quality of life in Mali, particularly in the rural areas, by energizing tasks that are now largely accomplished by human muscle power and (b) to contribute to the alleviation of Malian dependence on increasingly costly fossil fuels and firewood with its negative economic and ecological consequences. A third purpose is to gain a better understanding, based on close observation, of the social and economic consequences of introducing renewable energy technologies in rural Africa.

To accomplish these goals, the project proposes a coordinated program — involving up to eight Malian agencies — of institutional support, applied research and development, village surveys, and field demonstrations in over twenty sites. In sum, the project aims to prepare Mali to introduce renewable energy technologies in rural areas on a wide scale.

Two types of preparation are required. First of all, there must be a sustained effort to adapt proven applications to the Malian situation. The substitution of local for imported materials used in the fabrication of various devices will be as important as making design modifications that increase durability under Malian conditions. Secondly, while the hardware is being adapted, efforts must also be made to determine effective ways for village groups or family units to take over the ownership, operation and basic maintenance of the new devices. Both types of preparation will have to be successfully completed for each new technology before it will be possible to consider it for wide-scale distribution to villages, not only in Mali but possibly elsewhere in the Sahel as well.

The Malian organization which will be the locus of this preparatory effort is the Solar Energy Laboratory, a division of the Direction Générale de l'Hydraulique et de l'Energie, Ministry of Industrial Development and Tourism.

The Laboratory was created in 1964. After a period in which it did some interesting work developing flat-plate solar water heaters and solar stills using locally available materials, the Lab's productivity slumped and it is not now doing any applied research work of note. Though staffed

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*A more detailed description of the project is contained in Appendix D.

by a small number of capable engineers, it has little sense of purpose and direction. The location of the Lab's workshop and offices in temporary quarters belonging to the Malian army and the complete lack of appropriate measurement apparatus have made matters worse. Nonetheless, given a suitable program of applied research and the instruments to carry it out, the Lab could effectively undertake the preparatory task that is required.

This belief is strengthened by the intense personal interest demonstrated by the Director General of the service to which the Lab reports and by his Minister, both in the project and in seeing that the Lab perform its designated role effectively. Furthermore, the project has elicited support and cooperation on the part of seven other Malian agencies that will participate in one aspect or another.

The project consists of five distinct phases. An in-depth evaluation of research and development work accomplished by the Solar Energy Laboratory in Phase I will be required before the project proceeds to Phases II, III, IV and V.

The first phase will have two parts. One will consist of material, technical and training support for the Solar Energy Laboratory, the primary recipient, and for the National School of Engineering, the Ecole Normale Supérieure, and the Central Veterinary Laboratory. The second part will involve the installation of four pumps powered by arrays of photovoltaic cells.

These pumps will be placed in the ground at the beginning of the project for two reasons. One is to provide a demonstration effect, to show that the project has as one of its main purposes the production, from solar energy, of goods and services for use by the rural population. The second reason is to gain experience from the use of photovoltaic pumps under harsh climatic and physical conditions. The lessons learned in the realms of equipment durability, technical performance and social use would be applied in the more carefully prepared tests that follow in a later phase of the project. Since each proposed demonstration would take place under the aegis of an existing institutional program, risks regarding supervision and maintenance would be minimized.

In order to capture the informational lessons of these "early starts", technical and socioeconomic data will be gathered at each site. This information will be of value in structuring the broader survey effort that

is contemplated in Phase II. Three short-term specialists -- an energy scientist, a social scientist, and an economist -- will develop a scope of work and methodology, in consultation with the Malian agencies concerned, for gathering "early start" data and making it available.

The four early starts would have different uses. Two would be installed in the zone of the Mali Livestock II project, one at Kamodibo, near Dilly, and the other in the village of Demba Diawara, 15 km away, to provide water for villagers and their animals. A third pump would irrigate a portion of the fields of a market gardening cooperative in Mopti. The fourth would be installed at Samanko, a village for the rehabilitation of lepers, 15 km from Bamako. It would be easily accessible to Lab personnel, School of Engineering and Ecole Normale Supérieure students and others for training and demonstration purposes.

Support for the Solar Energy Laboratory in the first phase will consist of several elements. Most important is the establishment of a program of applied research aimed at perfecting the adaption of certain energy technologies for use in Mali. The Lab would be assisted in the elaboration of its program by the assignment of an American renewable-energy scientist for the first two years of the project. To allow the Lab to disengage from its partial, uncertain dependence on military space, the project will provide for the financing of new facilities, including offices and a workshop, at a site provided by the Malian government. It will also contribute equipment for the new facilities, particularly items needed for the conduct of the research program. U.S. training of selected members of the Lab's staff is also contemplated. Furthermore, during the early years of the program, financing for a portion of the Lab's expanded operating costs will be required.

A tentative list of priorities for the Lab's research and development program, developed collaboratively between the PP team and the Lab's staff, includes (a) testing and improvement of solar water heaters for urban uses and rural institutions (dispensaries, schools, etc.), (b) testing and improvements on crop/fish dryers, (c) development of an efficient, wood-burning stove using readily available materials, and (d) development of an efficient photovoltaic battery charger, emphasizing reliability and ease of operation. Other priorities would be added to the list in the course of Phase II (village surveys) and as the Lab increases its capacity to take them on.

The second phase, eighteen months in duration (including a preparatory period), would begin six months after the start of Phase I. It would involve coordinated activity directed by the Institut d'Economie Rurale with the participation of several other government agencies* (which have already established a project committee for this purpose) and the Peace Corps. During Phase II, meteorological and socioeconomic studies would be undertaken at 25 villages determined (by the project committee) to have potential for experimentation with devices using alternative energy sources. Initiation of the studies would be preceded by a training program for enumerators (2 to each village) and for four mid-level supervisory teams, each of which would cover a geographic zone and periodically visit the village sites in its zone. These teams would consist of a Malian controleur and a Peace Corps Volunteer, both appropriately trained in survey techniques.

In addition to the collection of data, a crucial aspect of Phase II would be the selection of village cadre who would later assume responsibility for the operation and maintenance of the device or devices to be installed. Selection of the cadre will be a function of village preferences, inter-action with the supervisory survey teams, and the characteristics of the devices to be introduced.

The major output from Phase II would be village level reports indicating (a) socioeconomic base-line data, (b) local availability of energy sources (wind, insolation, biomass, etc.), (c) village preferences as to tasks to be energized, and (d) potential village capacity to operate and maintain energy devices. At the end of Phase II, 20 of the most promising of the 25 villages surveyed would be selected by the project committee for the introduction of energy devices in Phase III.

Prior to the initiation of the third phase, a rigorous review and evaluation of the research and development work of the lab would be conducted by a team of three energy scientists.** The review would focus

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*In addition to the Institute, participating agencies would include rural development "Operations", the Meteorological service, the functional literacy agency (DNAFLA), the community development service (Animation Rurale) and the Cattle and Meat Board (OMBEVI).

**For example, Dr. Djibril Fall, Director of the Institut de Physique Météorologique in Dakar; Dr. Eric Ferguson or Mr. Bernard Meunier, both consultants to the Club du Sahel; and a U.S. energy specialist.

on whether the measuring, testing and modification work performed by the Lab was good enough to assure confidence that its renewable energy devices could be tested in the field.

If the review were predominantly negative or mixed, Phase III would be delayed and Phases I and II extended while appropriate modifications were made and completed. The point is that village testing would not occur until the devices were considered to be ready for field application.

In Phase III, which would last 2 1/2 years, several different devices and applications would be tested in the villages selected. Villages would contribute part of the cost, with the remainder subsidized by the project. Performance would be watched with some care, and the social and economic changes that result from the introduction of the new technology would be observed and recorded. One of the Solar Energy Laboratory engineers would direct the project in this testing phase. The Lab itself would continue to make adjustments to the devices being tested as experience is gained during Phase III.

Operation and basic maintenance of the devices would be carried out by the village cadre. They would receive technical support from the Solar Energy Laboratory. Meanwhile, the data-gathering network would continue to function, with one enumerator observing and recording socio-economic data at each village site. The supervisory teams would continue to make periodic visits. This work would be reinforced by the continued guidance and consultant services being provided by IER, a consulting U.S. energy specialist, and the consulting social scientist.

The fourth phase of about six months would be devoted to a detailed analysis and evaluation of the experiments. Base data collected during Phase II before the devices were introduced would be compared with data collected after more than two years of use of the new technology. The evaluation would attempt to determine whether the project had provided answers to the questions posed in the Project Identification Document:

1. Which technologies are most susceptible to local operation and maintenance and, in each case, how should local control be organized?
2. What will be the impact of the new technology on income levels, income distribution and social welfare in the community? Who benefits the most? the least? not at all?

3. Which devices perform and endure well in their physical setting?
4. How do the costs per unit of output compare with alternative sources of energy that could be used in the same setting?
5. Are the technologies culturally and socially acceptable to those who use them, or do they require changes in habits that are considered unacceptable?

The evaluation would take place under the joint direction of the IER Evaluation Unit and the Solar Energy Lab's project director and would utilize consultants, supervisory personnel, DNAFLA, and such others as may be able to contribute in the light of the situation at the time. A six-month effort to compare the village sites before and after the tests, with full exploration of the performance of the devices, the villagers' adaption to them, and the socioeconomic changes induced, would be required. An evaluation report would be printed and distributed.

As the results of the evaluation begin to emerge, a fifth phase would be considered. Phase V would consist of transitional support to the Solar Energy Laboratory. The project would seek to collaborate with other donors in promoting proven devices for private sector production and distribution in both urban and rural areas. It would be desirable to set up licensing arrangements so that the Lab would receive royalties from the sale of these products and thereby finance further research and development activities. Phase V would be developed in greater detail during the later years of the project, and funding for its implementation would be added through a PP amendment during the fifth year.

Relation to Overall AID Objectives in Mali

During the life of the project, beneficiaries would be rural families in villages where test devices are to be installed. The use of renewable energy sources can provide a number of new benefits: improved quantity and quality of water for human and animal consumption; greater availability of protein and vitamins through solar fish and crop drying as well as the introduction of vegetable gardening; reduced consumption of scarce firewood resources; reduction in labor devoted to grinding cereals, obtaining water and collecting firewood; wider availability of vaccines through refrigeration; lighting for community buildings; and the availability of hot water for dispensaries. All of these improvements would be of direct

benefit to rural groups and individuals. If the project is successful in finding ways to spread the tested devices on a much wider scale, there would eventually be countless rural beneficiaries in Mali and in neighboring Sahelian countries as well.

To the extent that a solar or wind-powered device does not provide a new benefit but substitutes either for a fossil-fuel apparatus or for imports, the primary beneficiary is the country. The importance of saving foreign exchange by not importing costly refined petroleum products into a country like Mali is obvious enough. Less obvious is the foreign exchange saving that would result from widespread photovoltaic cell battery rechargers which could recharge batteries over 100 times. Battery-operated radios, flashlights and other appliances are used so widely that Mali imported $1.3 million worth of batteries in 1976.

As a whole, the project is aimed very clearly at AID objectives for benefiting the rural poor, for pursuing environmentally sound projects, for helping women, and for encouraging the use of renewable sources of energy. The project also complements other AID efforts that concentrate on individual sectors or areas in Mali.

Specific Beneficiaries

The initial project beneficiaries will be the Bambara cultivators and Peul and Maure herders living in or near the villages of Demba Diawara and Dilly north of Bamako on the Mauritania border, Bambara truck gardeners working at Mopti, and the former lepers, representing a wide variety of ethnic groups, that are in residence at or near the training center of Samanko. The traditional ways of life of the Bambara, Peul and Maure are representative of indigenous patterns of culture that prevail throughout rural Mali. Their study will provide a good first test of project benefits. For, as the Social Soundness Analysis (Appendix C) indicates in more detail, the superficial ethnic differences that appear to separate Malian peoples are of less significance than the underlying institutional similarities that unite them.

If successful, this initial project phase will be followed by one that is more comprehensive; it will extend project benefits to include representatives of the Malinké, Sarakollé, Dogon, and Sonrai segments of Mali's rural population.

Relationship of Project to Other Donor Activities in Mali

As a result of data gathered by USAID and the PP team, it is clear that the proposed project will not duplicate or conflict with programs of other donors in Mali. No other donors are planning major renewable energy activities in Mali with the exception of the European Development Fund. (Canada is planning to finance two PVC-powered pumps for water system projects in small towns.) The European Development Fund (FED) is planning to finance several PVC-powered pumping projects, a total of 18 by 1979. The FED will finance 50-75 percent of the cost of the installation provided the requesting agency will finance the remainder. A large proportion of the requests are from missionary organizations, such as the Mali Acqua Viva program which is run by Father Verspieren of San. These projects are usually being carried out under very carefully controlled conditions, both with respect to access to the water and to the care and maintenance of the technology. While they are undoubtedly of benefit to the country, they do not involve the institutional development and data collection efforts that are such important features of the present project. Also, they involve the introduction of a single pre-selected technology, not the broad range of technologies that the present project seeks.

Mali's efforts to coordinate its solar energy activities with those of its Sahelian neighbors are reported in detail in section 3(d).

In addition, a team of solar energy experts, organized by the Club du Sahel, visited Bamako during the stay of the PP team, resulting in a productive exchange of views. The Club's experts are fully cognizant of the project and, indeed, suggested one of the items for the Lab's priority research program (battery charger).

SOCIAL SOUNDNESS ANALYSIS SUMMARY

At each stage in its development, the project is designed to build upon and further strengthen existing Malian institutions, both indigenous and modern. In addition, a concerted effort will be made to encourage the fabrication of renewable energy devices that clearly meet the most pressing needs of the rural majority and which can, in most instances, be taken over, operated, and maintained by their users.

A. Sociocultural Feasibility

To secure the background ethnographic data necessary to ensure an optimum fit between indigenous institutions and the new technologies, a social scientist (either an anthropologist or a sociologist with development experience in the Sahel) will join the project in a consultative role from the outset. It will be his or her responsibility to ensure that the survey and test phases of the project build upon the already available body of sound ethnographic information on traditional rural Malian society. He or she will assemble a working research library for the project and will maintain liaison with the Malian social science community. Collaboration with the latter is necessary to make certain that their useful experience is incorporated into research design, implementation, and analysis, and to ensure that Mali is left with a record of research results which will be of use in future studies of the cultural impact of technological innovation and economic change upon rural Malian society.

Because of the several decades of distinguished ethnographic research that have been conducted among Mali's major ethnic groups, the basic outlines of indigenous society are already well understood. Despite specific cultural differences, the underlying structure and function of autochthonous institutions among those groups most likely to be affected by the project -- the Bambara and Malinké, the Peul and the Maure, the Sarakollé, the Dogon and the Sonrai -- are fundamentally similar.

Among sedentary cultivators, those who practice mixed farming, and those who are fully nomadic herders, the unit of production, co-residence, and primary allegiance is everywhere the patrilocal extended family. Its core agnates typically comprise the local membership of the totemic patrilineage. As a valuable alternative basis of affiliation, associations,

either voluntary or based on age, are widespread. Most indigenous Malian societies are stratified on the basis of sex, ethnicity, caste, class and free or slave descent.

The traditional authority system is everywhere derived from the same principle of seniority that legitimizes decision making within the kin group. The community leader is typically the eldest responsible male member of the founding lineage of the local settlement.

All groups are to some extent Islamized, but traditional magico-religious beliefs and practices have either been syncretized with aspects of folk Islamic observance or fully retained. The worship of ancestral spirits and veneration of the supernatural forces believed to vitalize the natural milieu are still potent forces in all rural areas. Consequently, the bearing of "pre-scientific" cognitive processes upon the perception of cause and effect relationships necessary to the efficient operation of the new technologies will be carefully assessed during the survey and testing phases of the project.

Motivation to participate in project benefits will derive primarily from the need of the rural population for relief from some of the more arduous tasks associated with their essentially primitive indigenous technology. Sustaining an adequate water supply is everywhere a major problem. Women's work, gathering firewood and pounding grain, takes hours each day. The successful introduction of such devices as solar pumps, cereal grinders, and improved woodburning stoves would release many hours of labor time for reallocation to alternative productive pursuits. This would diversify, and thus strengthen, the material base of rural Malian society.

In order that this potential motivation be realized, the project will stress the necessity of ensuring that those whose traditional tasks are alleviated by the new technologies are allowed to reallocate time to alternative tasks from which they stand personally to benefit. It is assumed, for example, that a woman is more likely to be interested in adopting the new behaviors necessary to use an improved woodburning stove, a cereal grinder, or a solar pump, if she is allowed herself to reallocate the labor-time thus saved.

The survey and testing phases of the project are designed to identify those aspects of indigenous work organization -- the patrilocal extended family, age-based associations, village councils -- which can be productively

built upon in order to ensure that project beneficiaries are themselves able to acquire, manage, and maintain the new technologies. An equally basic objective of the survey phase of the project will be to collect the baseline technoeconomic and sociopolitical data essential to measure project results during the final evaluation phase.

Once their functioning is perfected, no major obstacles are foreseen as likely to impede the acceptance of the new technologies. The more critical variable appears to be the identification and utilization of viable local institutions that allow for control by the people the new technologies are intended to benefit.

To permit the two-way communication vital to the successful achievement of technological innovation, the survey and testing phases of the project will develop and assess a variety of communications strategies emphasizing the use of verbal and written materials prepared in the vernacular.

B. Spread Effects

After adequate testing and structural modification as required, the prospect for the diffusion of the new technologies appears to be good. They will have been tried out among all ethnic groups and in all of the environmental settings appropriate to their functioning. Many will have been installed in locations -- some of them will be placed at the sites of important government-sponsored enterprises -- where neighboring peoples will have an opportunity to observe their productive advantages.

No previous project in Mali has undertaken distribution at the rural level and under local control of new technologies such as those which this project proposes. With the possible exception of windmills, the fortunate absence of a legacy of past project failure greatly increases the probability that carefully tested, demonstrably efficient devices will be well accepted once the material means for their economical acquisition and maintenance are assured.

A few Malian merchants who may presently profit from the monopoly ownership of cereal grinders appear to be the only persons who might be adversely affected by the introduction of the new appliances.

To the extent that they make life easier in the countryside the new appliances are likely to stem the rural exodus rather than causing any major population displacement.

Malian women are clearly the single group that stands to benefit most from the project. However, as indicated, for such benefits to be fully realized it will be imperative that the labor-time women save is theirs to reallocate as they see fit. It will be a major objective of the survey and testing phases of the project to identify the mechanisms bv which they and other subordinate groups in Malian rural society can be assured an equitable share in project benefits.

TECHNICAL ANALYSIS SUMMARY

The technical feasibility of the renewable energy project depends on village needs, the availability of an energy source, and the properties of the energy-conversion device. Desirable properties include low cost, ease of operation, maintainability, long life, coincidence with village usage patterns, and possibility of construction with local materials. An outline of these considerations is given here. The subject is discussed in more detail in Appendix B.

Energy Needs

The energy needs of Malian villagers include:

Heating: sanitary hot water at 50°-60° C;
cooking at 100° C or greater;
sterilization of water at 100° C

Refrigeration: preservation of food, medicines, vaccines

Drying: of fish, meat, vegetables, fruits

Mechanical or Electrical Energy for:

- lighting
- cereal grinding
- water pumping for human or animal consumption or for irrigation
- refrigeration
- battery charging
- other

The most important needs for specific villages are to be determined in Phase II.

Energy Sources and Conversion Technologies

The renewable energy sources all derive from the sun. Geothermal and nuclear sources are not presently adaptable to village size although a geothermal resource exists at Lake Faguibine. Solar energy can be used directly, via photosynthesis, or via wind or flowing water. These utilization routes are listed below.

(a) Direct: Heat production for:

- cooking
- distillation
- refrigeration - absorption cycle
- drying
- sanitary hot water
- sterilization
- other

Mechanical or Electrical Production for:

- cereal grinders
- water pumping
- lighting
- refrigeration
- battery charging
- other

Heat production can be done with flat-plate or concentrating collectors. Mechanical or electrical energy production can be done via heat collection plus a thermodynamic engine or via photovoltaics which produce electricity directly.

(b) Via Wind or Water: The sun drives these two sources. Both can produce mechanical or electrical energy for the uses listed above.

(c) Via Photosynthesis:

Wood stoves for:

- cooking
- sanitary hot water
- sterilization

Biogas Conversion and Pyrolytic Conversion:

- for all uses listed under Direct

Evaluation of Energy Sources and Conversion Technologies in the Malian Village Context

(1) Availability of the Resource

The direct solar resource is by far the largest; although few good measured data exist. The average insolation is largest in the north and, because of clouds and haze, it decreases toward the south. It is largest in the dry season, when more more energy is needed, and smaller in the wet season

when less is needed. It is by far the most promising resource.

The indirect route via water power is not promising. The large rivers which run all year are too large for village size hydropower. The village-size streams dry up during the dry season.

The indirect route via wind power is marginally promising. The wind speeds in southern Mali, where most of the people live, are too low for economical energy production. The wind speeds in northern Mali, where fewer people live, apparently are large enough to produce economical energy, but measured data are scarce and sometimes suspect.

The indirect route via photosynthesis is less promising than direct conversion because (a) the route from the sun's energy to the final application is longer and basically less efficient (0.1%), and (b) photosynthesis requires water, a scarce commodity in Mali, and this route usually competes directly with food production. The only two processes of promise are planting of trees along with efficient wood burning, and biogas generation from manure or agricultural wastes. Biogas generation, using a moist technique rather than a slurry technique, which requires more water, produces gas while retaining most of the original fertilizer value of the agricultural waste. On the other hand, pyrolytic conversion is in direct competition with the fertilizer value of the agricultural waste since it produces only gas.

(2) Analysis of the Technology Needed to Convert the Energy Resource to Meet Needs

Sanitary hot water

Women rise early in the morning to heat water for washing and do it again in the evening. Wood is consumed. The alternative, solar water heating, is a well developed and inexpensive technology, but a unit specifically adapted to village use must be developed. It cannot rely on running pressurized water nor electricity for operation. It can be built with many materials available in Mali. Prospects: good.

Solar Cooking

The hot water type using a good flat-plate collector avoids sun tracking requirements, allows cooking to be done in a shelter but cannot cook foods above the boiling point of water. It must be used during the middle of the day. The reflector type produces higher temperatures allowing broiling,

frying, etc. In addition to the disadvantages cited above, the operator must point it toward the sun and work in full sunshine. As a result of these operational difficulties the prospects are only fair.

Sterilization

This can be done with a high temperature flat-plate collector (100° C). Prospects depend on need for sterilized water. It is worth noting that closed wells using solar-powered pumps will avoid the contamination present in open wells, thus reducing the need for sterilization. Prospects: fair.

Refrigeration by Absorption Cycle

This requires equipment that is relatively expensive and mostly imported. The needs determined in Phase II may determine whether the price is affordable. Operation from the gas produced by a bio-digester is a possibility since the gas flow can be continuously used, eliminating gas storage requirements. Prospects: fair.

Drying

Traditional methods of drying may be good enough for many fruits and vegetables, and they require no capital expenditure. Since insects consume as much as half of fish weight during traditional fish drying, the expense of a dryer may be justified for this application. Construction uses many local materials. Prospects: good.

Distillation

Maintenance is a problem. The cost of $2 to $3 per cubic meter of water is too high for human consumption in all but the most exceptional circumstances. Prospects: poor.

Electrical or Mechanical Power from the Thermodynamic Cycle

Collection of heat by flat-plate collectors and use by a thermodynamic engine requires large collection areas and large heat exchangers because of the low collection temperature and resulting low efficiency. Consequently, the cost is high. Considerable maintenance is required. A large amount of material must be imported. Prospects: poor. If concentrating collectors are used, the operating temperatures can be increased, resulting

in a higher efficiency and lower materials requirements. However, tracking requirements, inability to use a large part of the diffuse radiation (up to 50% in Mali), and the unproven nature of the tracking mechanisms for long-term use in desert climates make this a doubtful technology at present. Prospects: poor at present.

Electrical and Mechanical Power from Photovoltaics

The technology is high, it must all be imported and at present the cost is very high. However, simplicity of operation, low maintenance, long life and great versatility make this an attractive option. At present photovoltaic water pumps are operating in Senegal and Mali with considerable success. Versatility is excellent. (See fig. B-VI, page B-24.) The panels can drive any required function including heating functions. If the cost of photovoltaic cells drops according to DOE projections ($2/peak watt in 1984 and 30 cents/peak watt in about 1990) then the prospects for this technology will be excellent.

Water Power of Village Size

The resource is too limited. Prospects: poor.

Wind Power

The windmill is highly perfected for winds above 5 m/sec. These windmills must be imported at present. They require reasonable supervision and maintenance. For low winds, different types must be designed which can utilize low and variable winds. Prospects in southern Mali: very poor; in northern Mali: good.

Pyrolisis

The equipment is expensive, not yet reduced to village size and the process competes with fertilizer utilizations of, for example, peanut shells. Prospects: very poor.

Biogas

The biogas process retains the fertilizer value of the agricultural waste while producing a good quality gas. The installation is not cheap. Indian installations are about $250 for a family-size unit producing 2 -

cubic meters of gas a day. Storage of gas is difficult. Construction materials are predominately local. Maintenance, feeding the digester, and collection of the manure, etc. are somewhat demanding. Prospects: fair.

Woodburning Stoves and Tree Planting

Stoves can be constructed which allow more complete combustion and better heat transfer to the cooking utensil. Materials could be predominately local. Maintenance would be low. The cost could be reasonable. They should be combined with a tree planting program and better methods of wood cutting, e.g., saws and wood-splitting equipment (wedges and sledges). Trees compete with food production on land near villages and require water. Prospects: very good.

These considerations, presented in more detail in the Appendix, have been used to select promising technologies for possible introduction in villages in Phase III.

ECONOMIC ANALYSIS SUMMARY

This project would assist Mali in a five-year test for the purpose of learning whether small-scale renewable energy technologies can provide affordable and reliable alternatives to fossil-fuel technologies. As such, the project has been designed to produce information and answers to questions rather than physical output. The renewable energy devices that are to be intensively tested at 20 village sites will of course produce goods and services. Yet the significance of their output will be slight compared to the insights into their economic and social feasibility that may be expected by the end of the project.

The technologies to be tested vary greatly in sophistication and cost. At one end of the spectrum, an improved woodburning stove made out of local materials, if it can be developed, might save up to 80 percent of the firewood now used to cook a meal over a traditional open fire. While social acceptability would have to be proven, the economic benefit to the Malian family and to the society could be easily demonstrated. At the other end of the spectrum, the photovoltaic pump is an expensive high-technology device. Technically, all indications at present are that it will function well in a Sahelian climate, though that too will be tested during the life of the project. Technological sophistication is not likely to change: photovoltaic cells will probably never be produced in the Republic of Mali. Yet the cost of the cells may fall so drastically, if present predictions come true, that PVC pumps and multi-purpose PVC units could have a great impact on life in rural areas. The economic question to be answered is: under what conditions will PVC devices become competitive with those using fossil fuels? Enough is known about the costs of PVC technology to attempt an answer to the question.

In the case of other renewable energy devices that are proposed for testing under this project, such calculations cannot be made at this time. As is made clear elsewhere in this Project Paper, the Solar Energy Laboratory has considerable R&D work to do on these devices before they can be considered ready for village testing. The possiblity of improving efficiency and of substituting local for imported materials may have a great

effect on costs. There are a number of other variables as well. For the purposes of economic analysis, therefore, it seems reasonable to limit detailed examination to one of the "early starts" in which a photovoltaic pump will be installed on an existing vegetable irrigation project, where its performance and costs can be directly compared with a diesel pump.

The analysis itself will be found in Appendix I. In summary, it can be said that the price of a 1300-watt photovoltaic pump delivered to Mopti would be $31,000. This cost reflects the savings that would accrue if the solar panels are ordered directly from the manufacturer in the U.S. It also reflects a quotation of $14 per watt (peak) for the panels themselves and $1.80 per watt (peak) for the hardware that goes with them.

Mali's Génie Rural, the rural engineering service of the Ministry of Rural Development, has estimated that another $9,800 will have to be spent for a fence to protect the solar panels and pump from animals and for a 160-cubic-meter storage tank. The assumption today is that storage is required because the solar pump produces its greatest output in the heat of mid-day when local farmers retire to shadier spots and because it will pump only on sunny days from a few hours after dawn until a few hours before dusk.

A well will cost $6,500, and given the newness of PVC installations in Mali, an expert will have to come from France to verify that it has been properly done before the switch is thrown. Spread among four early starts, his costs will be $850 per installation. The total cost of the Mopti pump will thus be $48,150. It will irrigate 1.6 hectares.

A diesel pump, by contrast, costs only $10,000, including the cost of a similar well, and it will irrigate 3.4 hectares. The lifespans of the two pumps differ, with the PVC pump expected to last 15 years while the diesel would have to be replaced after three to five years. It is also assumed that the PVC pump requires only half the repairs of the diesel.

At current fuel prices and for all positive real rates of interest, the solar technology is more expensive than the diesel technology. When the real rate of interest is 1 percent, the solar pump costs three times as much as the diesel pump with a five-year lifespan and 2.6 times as much as the diesel with a three-year lifespan. In fact, if the solar panels were cost-free, at a real rate of interest of 1 percent, the solar pump would still cost 1.6 times as much as the diesel pump with a three-year lifespan. Only

a negative real rate of interest, which would occur if the inflation rate were extremely high, would make the PVC pump competitive under the cost and other assumptions used above.

It thus seems clear that two events must take place before PVC pumps become competitive in a situation like that of Mopti. This would be true even if the cost of photovoltaic cells falls as sharply as is predicted. First, the cost of diesel pumps and the fuel to run them must rise substantially. Second, cost elements other than those of the pump and solar panels need to be substantially reduced. These include transportation (shipments in future will have to be by sea rather than by air) and local installations. Natural fencing or fencing of sturdy local materials will have to be substituted for imported chain-link fences, and the need for expensive storage tanks will have to be thoroughly examined. The experience gained from the Mopti pump and from other PVC pumps expected to be installed at later stages in the project should provide valuable insights as to how these costs might effectively be reduced.

ENVIRONMENTAL CONCERNS

The Initial Environmental Examination submitted with the PID was considered generally satisfactory by the PID review committee, but the PP team was requested to expand it to take into consideration (a) building construction, (b) water impoundment, and (c) water tables. (See PID review cable, Appendix P.)

An expanded IEE covering these issues was submitted by USAID/Mali on June 2, 1978, recommending a negative determination. In preparing the revised IEE, the PP team engineer concluded that construction of a new Solar Energy Laboratory on the outskirts of Bamako would pose no environmental threat. Nor does the present project envisage water impoundment.

The larger photovoltaic pumps might, however, present a danger to water table levels in certain areas of Mali. At the present time, the "early starts" are the only pump sites that are definitely determined. Of the four, the two wells intended for the Dilly area are the ones that might permanently lower the water table. At the conclusion of the PP team's stay in Mali, the Division Hydrogéologique of the Direction Générale de l'Hydraulique et de l'Energie was in the process of testing bore holes in the Dilly area with sustained pumping. It had determined that sustained pumping did not lower the water table at one village site, Demba Diawara, but the results for the other site, Kamadibo, were not yet available. Assuming the tests at Kamódibo reveal no danger to the aquifer, it would still be desirable to have the American hydrogeologist who is assigned to the Mali Livestock II project at Dilly verify the recharge rate before pumps are installed.

ADMINISTRATIVE FEASIBILITY

The Solar Energy Laboratory will benefit most from this project anc accordingly be expected to play a crucial role in the test phase. As ir cated in the Project Description, the Lab has not distinguished itself b its accomplishments in the past few years. Outside observers, including du Sahel consultants and members of the PP team, have found the Lab to b lacking both in its sense of mission and in its ability to make do with what little it has. From the standpoint of someone familiar with the wo of laboratories of this kind in the U.S., the Malian Solar Energy Labora is a disappointment. Its specific faults are revealed in the PP team energy scientist's assessment in Appendix E.

The Lab's engineers admit readily that their organization is not now doing any applied research worthy of the name. They are unanimous in maintaining, however, that the Lab is severely crippled by a number of factors. Foremost is the fact that its operating budget, exclusive of salaries, is only $11,400 per year.* Funds allocated to the Lab to purch equipment are equally scarce. In 1977 and 1978 the Lab was given access to $29,300 for equipment each year. Last year it was able to get only one-half of that amount, and this year a large portion of it will be devoted to vehicle repair and replacement. It is true, however, that operating and equipment funds have not always been put to best use in the past. An expensive drafting table, for example, might have been foregone in favor of a few basic measuring instruments such as thermometers. Just the same, the GRM's complex import requirements make it almost impossible for a small agency to import equipment.

Secondly, the Lab has received outside support from two organizations (UNIDO and CIMADE, an ecumenical aid agency based in Paris) that have wanted to emphasize the Lab's role as producer of hardware rather than as a research organization adapting solar technology to Malian conditions. The desires of these donors have thus pulled the Lab one way in its effort to get funding, while the programme proposed here would draw it back in a very different direction. The Director of the Lab has worked hard to obta support from the outside, but he has not provided the kind of scientific

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*This is nonetheless an increase from even lower amounts, $2,200 in 1972 and $6,600 in 1975.

direction and purpose that the Lab requires. The key question is whether the technical and material support provided by this project will suffice to get the Lab moving in the right direction and at an appropriate pace.

The conclusion reached by USAID/Mali and the PP team, after a long and frank discussion of the Lab with the Minister and the Director General who supervise the Lab, is a qualified yes. The Malian officials mentioned were categorical in their assurances that the GOM would do everything necessary to put the Lab on the right track. In fact, some long and very open discussions of the Lab's failures between its staff and the PP team may have jolted the former into an awareness of the need for action.

To make sure that momentum is achieved and maintained, this project would provide the Lab with vitally needed scientific measuring equipment at the outset, along with technical assistance in setting up an appropriate research program. The project would then build and equip a new Laboratory and workshop of reasonable dimensions. About two years from the submission of this PP and some 20 months from the expected start of the project, there would be an intensive evaluation of the Lab's performance. (See Appendix E). If the determination were unfavorable, the project would not proceed to Phase III - and beyond - unless and until corrective action were taken. This condition is understood and accepted by Lab personnel and by their superiors in the Malian Government. The PP is thus submitted in the expectation that the Lab will be performing as required at the time of the evaluation but with the safeguard that the project is to be restructured if it is not.

Evaluation Unit, Rural Economy Institute

The Evaluation Unit has been chosen to provide organizational help and a director for the Phase II village surveys because of its experience in conducting surveys of this kind. The head of the Unit, Dominique de la Croix, is a French agronomist who is leaving Mali in July. He understands the nature of the Phase II survey and believes that the Unit can provide a good director for it and can organize the recruitment and training of enumerators. He has in fact suggested someone to direct the survey. In the absence, however, of the Director of IER (who was briefed on the project when the PP team arrived but who was away when the team completed its work), the Evaluation Unit head could not make any firm commitments on behalf of his agency.

It is true that the Evaluation Unit is not heavily staffed. In addition to de la Croix, there are three senior Malian staff--Moussa Traoré, Mme. Sy, and an animal scientist who is working on an evaluation of the Mopti Livestock Operation. Traoré will probably replace de la Croix in the summer of 1978 and will have his hands full with ongoing surveys and evaluations. Mme. Sy, an economist, is expected to spend the 1978-79 academic year studying in France. One of two newer and more junior staff members, Amadou Samaké, will be absent for two years at the University of Ibadan. This leaves only five individuals to staff the unit in 1978-79: Traoré, the animal scientist, de la Croix's successor (if any), a young Frenchman doing alternative military service, and the second middle-level staffer. The last-named is de la Croix's candidate to direct the project survey. He is considered to be able, bright and hard-working, if still somewhat inexperienced. Additional support and guidance for the Unit may become available if the Ford Foundation decides to assign an agricultural economist there.

Given the uncertainty about staff strength in the coming year and de la Croix's inability to commit the Unit in any definite fashion, USAID will be obliged to follow developments closely and ensure that the Unit will be able to play the role designed for it.

To help the Unit prepare for the survey phase and to maintain momentum, the project would ask the social anthropologist and the economist who visit Mali in January 1979 to work with the Unit on details of survey design and on plans for recruiting and training enumerators. A few months later, perhaps in April or May, 1979, the project's consulting social anthropologist, who would by then be working on the collection of existing studies, should visit Mali and make it a point to see that plans for the survey are progressing satisfactorily. He or she could make a major contribution to the design of the survey at that time.

Direction Générale de l'Hydraulique et de l'Energie

The Director General supervises the Solar Energy Laboratory and will also serve as chairman of the Project Committee coordinating the activities of Malian agencies involved in the project. Reporting to the Director General are a number of other divisions in addition to the Lab. These include Hydrogeology, Hydrology, Thermal and Hydroelectrical Energy,

Hydraulique Rurale, Urban Water Supply, and Opération Puits (Wells). Each of these divisions has a somewhat different perspective on energy matters. Nowhere in the Direction Générale is there an office or an individual who is responsible for looking at the entire energy picture and for developing energy policy for the country.

The Director General plans eventually to have two deputies, one of whom would be in charge of energy matters; but he does not think that any of several junior engineers who staff his department have yet had enough experience in the field to take on such a post. The Director General therefore has kept overall energy policy, to the extent there can be said to be any, in his own hands. He would very much like to have the project point the way toward rational choices on energy matters and hopes that by the end of the project it will be possible to articulate a clear policy for the rural areas of the country.

The Director General is therefore quite receptive to the idea that by the third year of the project, when two or three of his junior staff should have distinguished themselves and had sufficient field experience, funds be set aside for two of them to take a course of study in the U.S. This would be aimed at providing them with an overview of energy matters as well as some of the tools of economic and social analysis that would enable them to work on energy policy after their return to Mali.

Co-Ordination With Other Organizations in the Sahel

Mali is one of three Sahelian countries that are endowed with solar energy research organizations; Niger and Senegal are the other two. The organizations are:

Mali: Laboratoire de l'Energie Solaire

Niger: Office de l'Energie Solaire (ONERSOL)

Senegal: Institut de Physique Météorologique, Faculté des Sciences, Université de Dakar

Laboratoire des Semi-Conducteurs et d'Energie Solaire, Faculté des Sciences, Université de Dakar

Institut de Technologie Universitaire (ITU)

In Senegal there is also a joint Senegalese-French company for the fabrication and marketing of solar energy devices called the Société Industrielle Nationale d'Application d'Energie Solaire (SINAES).

Under the auspices of the West African Economic Community (CEAO) and the Interstate Committee for Drought Control in the Sahel (CILSS), representatives of solar energy organizations in Mali, Niger and Senegal met together with delegates from Chad, Ivory Coast, Mauritania and Upper Volta in Bamako in September 1976. The colloquium recommended, among other things, that national research centers be strengthened where they exist and created where they do not, and that a regional center for research and promotion of solar energy use also be created.

The colloquium appointed an Ad Hoc Committee, which met subsequently in Niamey in March 1978. Mali, Mauritania, Niger, Senegal and Upper Volta were represented. The Committee, to consist in future of two solar energy researchers and one government representative from each country, plans to meet once a year. It will undertake scientific colloquia and support missions to promote coordination among research centers and researchers. The Ad Hoc Committee also requested the CEAO to take the necessary steps to insure an adequate exchange of information on solar energy research and results. In addition to requesting funding for the existing institutions from the CEAO, the Committee also specified that the proposed regional center should undertake research programs that required greater resources than those available to the national centers.

This initiative having been taken by the CEAO member countries, the PP team considered that the present project should not attempt to introduce another element of coordination with the other Sahelian research organizations. Encouragement of the work already begun in the CEAO context should be sufficient.

FINANCIAL PLAN

In light of the implementation arrangements discussed in the next section, it is recommended that U.S. funding be made available in two major tranches: $2.7 million to finance Phases I and II and the remaining $1.2 million to finance Phases III and IV, subject to the results of the evaluation scheduled to take place in June 1980. This method of funding can be accommodated within the obligation schedule for this project included in USAID/Mali's FY 1980 ABS submission: FY '78 (August) $1,500,000; FY '79 (November) $800,000; and FY '80 (October) $400,000, thus completing first tranche funding. Second tranche obligations would include: FY '80 (August) $400,000 and FY '81 (November) $814,000.

Waiver

A waiver of section 110(a) 25 percent host country contribution will be necessary.

Justification

(a) Mali belongs to the group of relatively "least developed countries" as identified in UNCTAD classifications.

(b) Financial constraints and other considerations have been the basis for waiving this requirement in the cases of other bilateral projects with Mali, and these considerations are equally applicable to this project.

(c) The host country contributions to this project will be substantial. In person years they will far exceed U.S. advisory inputs, but at a salary scale which is a small fraction of the advisory scale. Additionally, villagers themselves will be contributing significantly with their labor and management of activities and devices.

(d) Host country financial contributions will increase over the life of the project. This is appropriate for this kind of project, which experiments with a relatively new and costly technology which should diminish in price in the future. The project explores a new approach to rural energy problems and attempts to verify the validity and practicality of the approach. Increased GRM and village inputs will be justified on the basis of the success of the project in achieving its purpose during the initial years.

Table I of the financial plan provides an itemized breakout of the commodities and services necessary to finance each phase. Equipment lists and prices are included in Appendices G and J. Table II contains a summary cost estimate, by each phase, showing the breakout of local cost and foreign exchange components.

TABLE I

($1 = 460 MF)

Phase I

Participant training:	photovoltaics (U. of Delaware) and solar thermal instrumentation and measurement procedures (Colorado State, Florida or Arizona State), 3-4 months each	$ 16,000
Commodities:	initial order of scientific equipment (Appendix J(1))	34,650
Vehicles:	small pick-up truck, 4-wheel drive vehicle and 4-door sedan for Lab (Appendix J(2))	29,000
Short-term mission (energy scientist, economist, social anthropologist), January 1979.		26,500
Support for School of Engineering (Appendix G(1))		38,500
Support for Ecole Normale Supérieure (Appendix G(2))		45,000
Support for Central Veterinary Laboratory biogas experiments (Appendix G(3))		38,000
Early starts:	solar pumps (4)	225,000
Construction of new Lab (850 m^2 @ $300/$m^2$ + paving, fences and roads)		350,000
Commodities:	scientific equipment for new Lab (Appendix J(3))	113,800
	office equipment and library material for new Lab (Appendix J(4))	25,310
	workshop equipment for new Lab (Appendix J(5))	65,300
Technical assistance:	energy sientist at Lab, 2 years	250,000
	Social anthropologist	29,000
Recurrent costs, Lab, 2 years @ $20,000		40,000
		$ 1,327,560
	10% contigency & inflation	132,800
		$ 1,460,360

Table I (con't)

Phase II

Training, Michigan Survey Research Center, 4 PC Volunteers	$ 12,000
Survey vehicles: 5 4-wheel drive (4 supervisory teams + survey director)	60,000
In-country training program for 65 enumerators & controleurs	10,000
Enumerators' salaries: 40,000 MF x 12 mos x 50	52,000
Village housing for enumerators: $100 x 25	2,500
Housing allowance for controleurs: 25,000 MF x 12 mos x 4	2,600
Controleurs' salaries: 50,000 MF x 12 mos x 4	5,500
In-country travel: survey director: 7000 MF x 100 days	1,500
Lab liaison engineer: 7000 MF x 75 days	1,100
Supervisory teams: 4000 MF x 1400 days	12,200
Vehicle operating expenses: 90 MF/km x 150,000 km (6 vehicles)	30,000
Operating expenses, co-operating agencies	25,000
Lab vehicle: mini-bus	13,000
Social anthropologist: 3 mos., 3 trips	21,000
Evaluation mission, June 1980	23,000
Meteorological measuring equipment for village sites	20,800
Office expenses for survey headquarters: mimeo maching, paper, etc.	15,000
Repair of Phase II demonstration devices	5,000
Test devices for Phase III: cost of fabrication & importation	587,000
Photovoltaic pump for Lab grounds	50,000
Support of worthy R & D efforts not known/foreseen at start of program	50,000
	$ 999,200
20% contingency & inflation	199,840
	$ 1,199,040

Table I (con't)

Phase III

Training program for village cadre	$ 10,000
Enumerators' salaries: 45,000 MF x 30 mos x 20	60,000
Controleurs' salaries: 55,000 MF x 30 mos x 4	15,000
Shipment and installation of devices at village sites	100,000
In-country travel expenses: Lab project director: 7000 MF x 20 days	3,100
Supervisory temas: 4000 MF x 3000 days	26,100
Vehicle operating expenses: 100 MF/km x 300,000 km	65,000
Operating expenses, co-operating agencies	75,000
Maintenance and repair of devices	70,000
Enumerator housing repairs: $50 x 20	1,000
Housing allowance for controleurs: 25,000 MF x 30 mos x 4	6,500
Social anthropologist: 6 mos, 6 trips	47,000
Energy scientist: 6 mos, 6 trips	50,000
Office expenses related to field testing	10,000
Participant training: energy policy (Hydraulique)	51,000
other	20,000
Recurrent costs, Lab, 3 years @ $20,000	60,000
Interim report preparation	10,000
Translation of interim report	7,000
Support of worthy R & D efforts not known/foreseen in Phases I & II	200,000
	$ 886,700
30% contingency & inflation	266,010
	$ 1,152,710

Table I (con't)

Phase IV

Social anthropologist: 3 mos., 2 trips	$ 19,000
Energy scientist: 2-1/2 mos., 2 trips	19,000
In-country travel by evaluation team	10,000
Final report preparation	15,000
Translation of final report	10,000
	$ 73,000
40% contingency & inflation	29,200
	$102,200

Recapitulation

Phase I	$ 1,460,160
Phase II	1,199,040
Phase III	1,152,710
Phase IV	102,200
	$ 3,914,110

TABLE II

SUMMARY COST ESTIMATE AND FINANCIAL PLAN
($US 000)

Use	Source	AID FX	AID LC	GRM FX	GRM LC	Peace Corps	Total
Phase I (8/78-6/80)							
Equipment		614					
Construction			350				
Technical Assistance		307					
Oper. Costs (Lab)			40		110		
U.S. Training		16					
Contingency (5%)		47	20				
Inflation (5%)		47	19				
Total		1,031	429		110		
Phase II (3/79-9/80)							
Equipment		381	300				
Phase II survey			147		20		
Lab R. & D.		50	50				
Technical Assistance		44					
U.S. Training		12					
Local training			10		5		
Equipment repair			5				
Contingency (10%)		49	51				
Inflation (10%)		49	51				
Total		585	614		25		
Phase III (9/80-3/83)							
Field test operations			432				
Lab R. & D.		100	100				
Technical Assistance		97					
Oper. Costs (Lab)			60		170		
U.S. Training		71					
Local training			10		5		
Interim report			17				
Contingency (15%)		40	93				
Inflation (15%)		40	93				
Total		348	805		175		
Phase IV (3/83-10/83)							
Technical Assistance		48					
Final Report			25				
Contingency (20%)		9	5				
Inflation (20%)		10	5				
Total		67	36		0		
PROJECT TOTAL		2,031	1,883		310		

IMPLEMENTATION PLAN

The schedule for project implementation is set forth below. The following implementation arrangements will be established for carrying out the project in accordance with the schedule.

Malian Arrangements

Although the Solar Energy Laboratory plays a key role throughout the project, successful implementation will require the coordinated efforts of some seven additional agencies, each with distinct and important missions. For this purpose, the Malian Government (GRM) has already established a de-facto inter-agency project committee containing representatives of these agencies. The committee met several times during the PP team's visit to review and discuss the proposed project. The committee is headed by the Directeur Général de l'Hydraulique et de l'Energie in the Ministry of Industrial Development and Tourism (to whom the Director of the Lab reports) and includes representatives of the organizations listed in Appendix K.

This project committee, with a single representative for each agency, will be officially established by the GRM and will meet from time to time under the chairmanship of the Director General to review the project and to resolve any inter-agency coordinating issues. Issues which cannot be resolved at the committee level will be referred by the chairman to the Minister of Industrial Development and Tourism, to whom the chairman reports directly, for higher level resolution. The committee will be the Malian mechanism for taking important project decisions, such as the selection of the twenty test villages.

Responsibility for the Solar Energy Lab's role in the project will be carried by its Director. For example, the Director will be responsible for the accomplishment of the Phase I tasks assigned to the Lab. He will also assign a senior member of his staff to serve as liaison between the Lab and the Phase II studies, thus assuring early and continuing feedback between the studies and the Lab's R & D work. Once the project moves into Phase III, the liaison officer would become the project director with responsibility for seeing that the Lab adequately supported the testing program and incorporated village experience into modifications of device design. The project director will continue in this role until the conclusion of Phase III.

The members of the project committee may designate senior members of their respective services to serve as day-to-day points of contact on project matters, or to assume special roles set forth in the project design. For example, the Institute of Rural Economy (IER) will designate a senior member of its Evaluation Unit to participate in the design of the baseline studies and the longitudinal socioeconomic studies contemplated in Phase II. Similarly, the Meteorological service will assign a staff member to participate in the design and evaluation of the village climatic studies.

AID Arrangements

USAID/Mali will designate a direct hire member of its staff to serve as project manager. The project manager will not simply handle AID's internal documentation requirements for the project but will also be responsible for all USAID implementation actions and for day-to-day contact between USAID and the GRM organizations. It will be his responsibility to monitor GRM activities related to the project, observe whether the inter-agency coordinating arrangements are, in fact, working and to facilitate, where possible and appropriate, better communications within the GRM in respect to the project. The project manager will also be responsible for monitoring and assisting the U.S. contract specialists, and serving as their point of comtact with USAID.

In respect to procurement, technical services will be competitively selected by the GRM and a contract awarded. USAID will be responsible for the procurement of U.S. equipment for the Solar Energy Lab, School of Engineering, etc. on the basis of the lists in Appendix J, which were prepared by the PP team's energy specialist and engineer after consultations with the Malians. Procurement waivers will be required for the "early start" pumps, for four-wheel vehicles, and for local architectural and construction services related to the Lab.

The implementation schedule, listing the more important actions to be accomplished during the life of the project and the dates by which they are to be accomplished, follows.

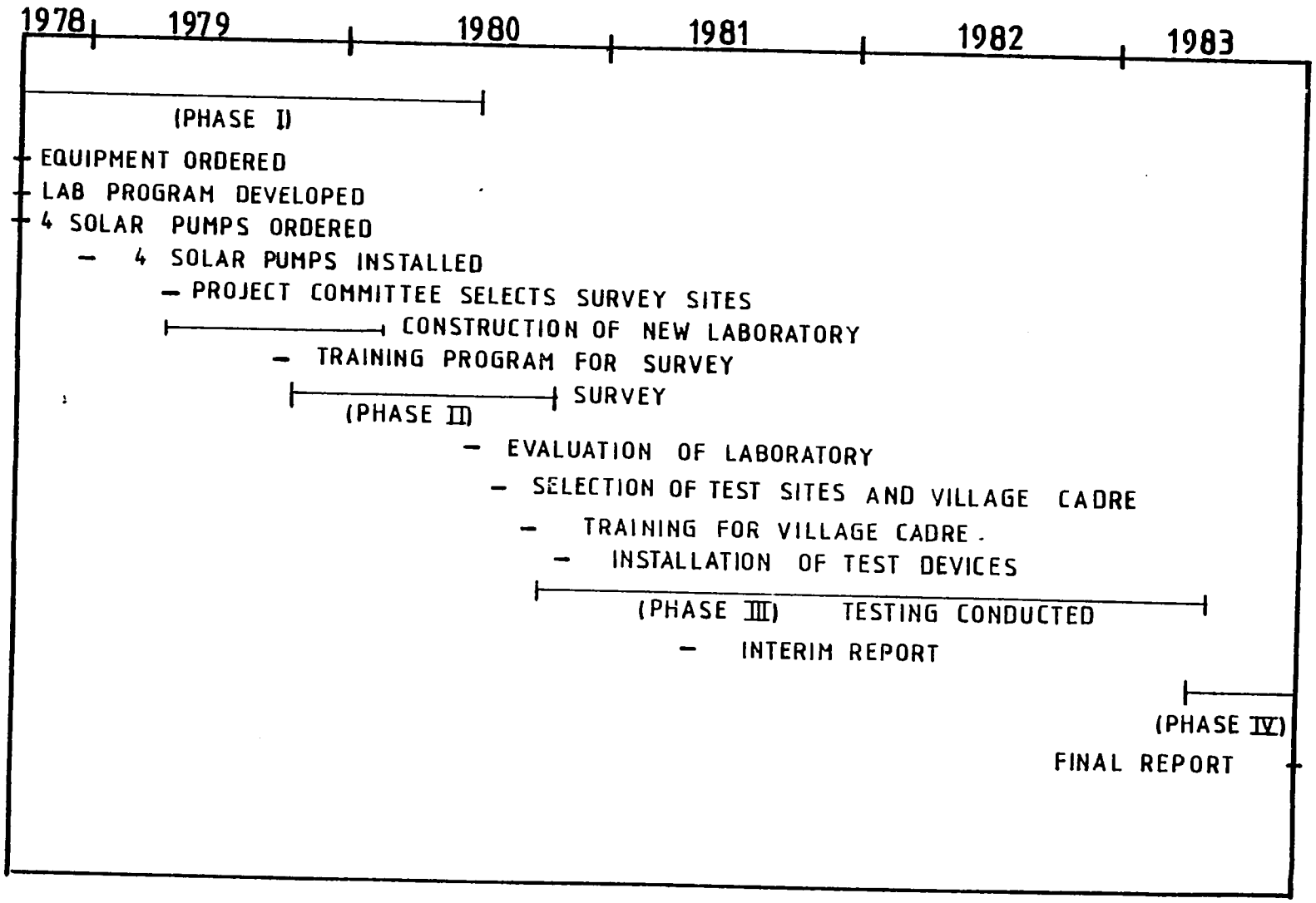
IMPLEMENTATION SCHEDULE

Event No.	Item	Date
1	Authorization	July 1978
2	Notice requesting expressions of interest for technical services contract issued	August 1978
3	Project Agreement signed	August 1978
4	Conditions Precedent for disbursement met	October 1978
5	Initial order of machine tools, scientific equipment and vehicles (8)	October 1978
6	"Early start" solar pumps ordered	October 1978
7	RFP issued to "short list" for technical services contract	October 1978
8	Recruitment of Peace Corps Volunteers initiated	October 1978
9	Technical services contract awarded by GRM	January 1979
10	"Early start" solar pumps installed	January 1979
11	Short-term economist/anthropologist/energy scientist mission establishes procedures for monitoring early starts	January 1979
12	Energy scientist arives in Mali	February 1979
13	Contract for construction of new Solar Energy Lab awarded by GRM	March 1979
14	Recruitment of Phase II survey personnel initiated by I.E.R.	March 1979
15	Project Committee completes selection of survey sites	April 1979
16	Construction of Laboratory begins	April 1979
17	Equipment and vehicle (1) for new Lab ordered	April 1979
18	Training program for survey personnel	September 1979
19	Phase II village surveys begin	October 1979
20	Laboratory equipment arrives	November 1979
21	Laboratory construction completed	January 1980
22	Laboratory evaluation conducted and determination made on whether to proceed into Phase III	June 1980
23	Imported material for village tests ordered	July 1980
24	Project Committee selects final sites	July 1980
25	Village cadre and Phase III enumerators selected	August 1980
26	Training program for village cadre and Phase III enumerators	September 1980

Implementation schedule con't.

Event No.	Item	Date
27	Village surveys end	October 1980
28	Test devices installed in villages	October/November 1980
29	Interim Report issued	April 1981
30	Progress reports submitted by Solar Energy Lab, social anthropologist and energy scientist*	October 1981
31	Phase III ends	April 1983
32	Phase IV evaluation begins	April 1983
33	Phase V begins	July 1983
34	Final Report issued	October 1983
35	Project ends	October 1983

*Also in April and October 1982.



RENEWABLE ENERGY PROJECT - MALI

EVALUATION PLAN

As indicated in the project description above, three major evaluations are scheduled to take place during the course of the project's five-year term. The first will take place in June 1980 (twenty months from project initiation, assuming it starts in October 1978). This evaluation will consist primarily of an in-depth assessment of the technical work of the Solar Energy Laboratory in developing, testing and modifying for village use the technologies which are to be deployed for field testing in Phase III. The evaluation will be undertaken by a three-man team of solar energy scientists including an African, a European and an American.

This evaluation will include a careful review of records kept by the Lab on the tests it will have performed on each device, the devices' cost and performance characteristics under given conditions, input and output records, and the general capability of the Lab to produce reliable prototype devices in the numbers foreseen in Phase III. Terms of reference for evaluation are contained in Appendix E. Since this evaluation is a precondition to a USAID decision to proceed to Phase III, it will be performed under AID auspices with the cooperation of the GRM.

The second evaluation will be the interim report on the Phase II village studies program scheduled for April 1981, or six months after the conclusion of Phase II. While the contract energy scientist and social scientist may assist in the organizational aspects of the report, it will essentially be a Malian report on the twenty five villages surveyed. The Peace Corps members of the supervisory teams will also contribute.

The report will deal with the results of the surveys in each village, including (a) baseline socioeconomic data, (b) village energy resources (climate, biomass, wind, etc.), (c) village preferences as to tasks to be energized, (d) village socio-institutional characteristics as they bear on control, maintenance, repair of energy devices and benefit distribution. Given the geographic and ethnic dispersion of the villages to be surveyed, significant differences in results may be anticipated. Nevertheless, the report should provide a basis for reaching conclusions on the validity and accuracy of the Phase II surveys and on their reliability for use in planning Phase III.

The third and final evaluation of the project constitutes the totality of Phase IV, which is a six-month joint evaluation of the project's 4 1/2 year experience, particularly of Phase III, the village testing program. It will be performed jointly by consultants provided by the U.S., USAID and the GRM agencies involved, including the Evaluation Unit of the Institute of Rural Economy. The terms of reference for the evaluation will be prepared by the contract energy scientist and social scientist for review and approval of USAID and the GRM agencies. Broadly speaking, the evaluation will attempt to measure the extent to which the project achieved the goals, purposes and outputs contemplated in the Logical Framework Matrix and the implications of such results for future renewable energy programs in Mali and elsewhere. For this purpose, the evaluation will be structured to answer the five questions posed in the project description, pages 5 and 6.

CONDITIONS, COVENANTS AND NEGOTIATING STATUS

No conditions or actions are required prior to the execution of the Project Agreement.

As a condition precedent to first disbursement the GRM will officially establish the Project Committee, referred to in the Project Description attached to the Project Agreement and endow it with the necessary rights and responsibilities to enable it to perform the functions contemplated for it under the project.

As a condition precedent to disbursement of funds for the construction of the Solar Energy Laboratory facilities, a USAID engineer must first approve in writing the final plans, specifications and bid documents for such facilities.

The Project Agreement will include a Covenant that the GRM will provide evidence that it has taken the necessary actions to assure that the Solar Energy Laboratory will be able to occupy and utilize a satisfactory new permanent site prior to the disbursement of AID funds for construction of the buildings to be situated for the Lab at that site.

The Project Agreement will include a Covenant pertaining to the procedures to be followed prior to a decision to proceed from Phases I and II of the project to Phase III, as set forth in the Project Description attached to the Project Agreement.

The Project Agreement will include a Covenant in which the GRM will undertake its best efforts to assure that the Solar Energy Laboratory will receive sufficient operating funds from the GRM budget to permit it to perform the functions which are envisaged for it in the Project Description.

MALI RENEWABLE ENERGY

PROJECT PAPER

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JUNE 1978

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ENERGY SOURCES AND USES IN MALI

Energy supply has been a dominant concern of Mali in the past few years. The drastic increase in the price of imported oil and heavy transport costs from refineries located in Dakar and Abidjan have brought a measure of urgency to the energy supply problem in a land-locked country severely hurt by the recent drought. Mali is spending relatively large amounts of foreign exchange on fossil fuels in order to keep its economy functioning. In the years ahead alternative sources of energy will have to be found if the present rate of growth of GNP is to be maintained. Awareness of this energy problem has resulted in efforts by local authorities and USAID to identify uses of alternate resources that are compatible with Mali's rural development priorities.

With an area of 1.2 million square kilometers, Mali has a population of 6.2 million. Approximately 85% of the population live in rural areas. The present per capita consumption of electricity is only about 15 kWh/year. Consumption is particularly low in rural areas, where there is no electrification. People in villages throughout Mali rely exclusively on traditional sources of energy such as firewood, charcoal, animal dung, agricultural wastes, animal power and manpower. Another important feature of the Malian energy system is that even in urban areas most electrical energy is consumed in air-conditioning and lighting administrative buildings and in supplying small factories, some of which are intensive energy consumers. Urban as well as rural households rely heavily on the traditional sources of energy, especially firewood and charcoal for cooking.

Oil and Natural Gas

Oil and natural gas requirements in Mali are totally met by imports. The use of oil and its derivatives has risen rapidly. With prices as well as quantities of imported oil rising since 1973, the country's external trade deficit has grown and is a cause of concern.* A breakdown of oil consumption

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*In 1972, the country was spending nearly MF 4 billion ($8.7 million) to satisfy its needs for petroleum products. By 1977, this amount reached MF 13.7 billion ($29.8 million) representing over 30% of the value of total imports, compared to only 18% in 1975).

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among different sectors of the economy is not available, but observation indicates that probably 50% goes to transport. The bulk of the remainder goes to the light industrial sector and the government. Very little goes to agriculture.

Hydroelectricity

Mali's portions of two important West African rivers, the Niger and the Senegal, have considerable hydropower potential. Large dams are being built at Selingué (43,200 kW) and planned at Manantali (140,000 kW), but until now little of the rivers' potential has been exploited. The two existing hydro-power stations, at Sotuba near Bamako and at Félou near Kayes, provided 34 million kWh in 1974, which represented about 52% of total energy consumption in that year. The remainder was supplied by 10 diesel generator stations scattered around the country in major administrative centers. Total installed electric power is now estimated to be 33,783 kW out of which 26,358 kW are provided by petroleum products and 7,425 kW by hydropower. Certain industries such as the COMATEX textile plant and the Dougabougou sugar mill have their own power stations. Cotton ginning plants and peanut oil mills use by-products for fuel.

Bamako's power needs will be met for a number of years by Sélingué. But while Bamako will have an adequate power supply, rural development will be increasingly subject to an energy constraint unless and until alternatives to fossil fuels can be economically exploited.

Traditional Sources of Energy

Except for firewood and charcoal no reliable data on consumption and reserves can be obtained. In 1965 the Service des Eaux et Forêts estimated the consumption of firewood to be 138,936 steres (or cubic meters) and that of charcoal to be 11,932 hundredweight. By 1973 consumption of firewood had almost doubled while that of charcoal rose by 25%. In 1975 more than 408,568 steres of firewood and more than 32,082 hundredweight of charcoal were used. The consumption of both is markedly higher today.

One probable explanation is price increases of kerosene, butane and propane relative to the price of wood. More households, particularly poor urban households, have to rely heavily on wood as fuel. While greater consumption of firewood has benefitted the wood cutters who live in villages along the main roads of the country, the pressure of demand on forest reserves is making wood more scarce and is causing its price to rise. In Bamako wood is already one of the major expenses of living.

More alarming is the ecological threat. Extensive tree cutting has resulted in the deforestation of vast areas, the undermining of the productivity of the land itself through soil erosion, and increasingly severe flooding during the rainy season. Requiring a permit for woodcutting has not resolved the problem since the cost of the permit has been shifted to the consumer in the form of higher prices.

Alternate Sources of Energy

The apparently favorable geographic location of Mali in the Sahelian zone, combined with the energy problems discussed above, has encouraged growing interest in solar energy applications. At the present time there are five solar pumps installed in the country, two of the flat-plate collector variety developed by the French company SOFRETES* and three of the solar panel type using American-made panels and French pumps by Guinard.** Under construction at Diré, on the bend of the Niger near Tombouctou, is a 50 kW station designed by SOFRETES to provide water, refrigeration and electricity.

All five existing installations were visited by the PP team during its stay in Mali. The team's observations follow.

1. Dioila SOFRETES pump

A SOFRETES pump was installed in 1975 at the dispensary in Dioila, an administrative locality 180 km from Bamako. It has provided water for the dispensary itself, for a school, and for the village. The cost of the pump was MF 18 million ($39,000), but digging a well, building the dispensary, and purchasing medical equipment and supplies brought the total cost of the project to MF 61.5 million ($134,000). Funds were contributed by several European church groups, funded through CIMADE, a French ecumenical aid agency.

The pump, however, has encountered a number of problems:

-It has been inoperable for several months and was dismantled when the PP team visited Dioila. Rust is a major problem.

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*Société Française d'Etudes Thermiques et d'Energie Solaire, B.P. 163, 45203 Montargis, France.

**The panels were provided by Solar Power Corporation, 5 Executive Park Drive, North Billerica MA 01862, and Solarex Corporation, 1335 Piccard Drive, Rockville MD 20850. Pompes Guinard is at B.P. 320, 92402 Courbevoie, France.

-The dispensary actually consumes little water and most families have their own well.

-The people of Dioila consider the water provided by the pump to be tasteless.

-Few animals are kept in Dioila itself. Most are in surrounding villages in the hands of professional herders.

2. Katibougou SOFRETES Pump

At Katibougou, a village 3 km from Koulikoro, the new capital of th 2nd Region and 80 km from Bamako, two pumps (one solar and one diesel) are jointly operating to supply water to a 2-hectare vegetable garden that provides food for students of the Rural Polytechnical Institute. It is also intended to be used for training students. One reason for having the two pumps there is to compare the two technologies under similar operating conditions. In fact, under present conditions the two pumps are not being compared. They work together as an integrated system. They supply water to the same field and when one is out of commission, the other one is used.

There are also problems with these pumps:

-They show a clear lack of maintenance.

-Inefficiencies: A very costly piece of equipment is not just deteriorating but is unutilized four months of the year when the students and staff of the Institute are on vacation, during a period when water is most needed.

3. Koni PVC Pump

Mali's first photovoltaic solar pump was installed at the Catholic farm family training center (CFAR) at Koni, 30 km east of Bla, in July 1977. Six panels manufactured by the Solar Power Corp. provide 900 watts of power for a 6-inch Alta-X pump made by Guinard. With the static water table at 18 meters, the pump produces 35 to 40 cubic meters of water a day. Water is pumped into a 120-cubic meter tank and can then be used either to fill four smaller tanks designed for retting kenaf or can be diverted to an enclosed banana stand of somewhat less than one hectare. As is the case with the PVC pumps at Nabasso and Tominian, the Koni installation was funded through Mali Aqua Viva, a private organization run by Father Verspieren of San, partly with private contributions from abroad and partly with support from the European Development Fund.

The only technical problem that has arisen with the Koni pump was the delamination of some of the panels soon after installation. As a result, all panels were replaced by the manufacturer with new ones of a different model (EM 3610). The undamaged ones were transferred to the Nabasso pump, replacing delaminated ones there. Noteworthy about the Koni pump is that its use appears to be strictly controlled by the personnel of the station. Outsiders are permitted to bring kenaf for retting (which takes three weeks of soaking in a tank) and are asked to pay by the bundle or by the tankful (MF 5,000). Consumption of pumped water for irrigation and for supplying water to the station staff as well as for retting (in season) does not appear to approach the capacity of the pump. The cost of the Koni installation, including the large tank and the wire fence around the pump and panels was estimated by station staff at about $54,000 (25 million MF).

4. Nabasso PVC Pump

Mali Aqua Viva put its second PVC pump in this large village of 3,000 inhabitants in October 1977. The panels are by Solar Power Corp. and the four-inch pump by Guinard. Pumped water is used for human and animal consumption. A Guinard representative noticed that a vegetable garden had sprung up in early 1978, but there was no sign of it in May 1978. This may well have been because large numbers of animals came to be watered in the dry months of March and April. Villagers state that there were difficulties and hard feelings as a result. The Nabasso tanks are installed so that the one draining into the animal trough is filled only after the tank for human consumption has overflowed. When the large animal population came to drink, they emptied their tank and some herders started filling containers from the spigots on the villagers' tank. As a result, the animals from outside villages and some of those from Nabasso were sent away toward the Bani River.

Water at Nabasso is provided without charge. An unpaid senior villager wipes the panels and keeps the enclosure with the pump and panels locked. He also keeps the handle to the valve that opens into the animal trough. In case of a breakdown, he knows only that he should send for the Mali Aqua Viva well team. The problems at Nabasso have clearly been more organizational and social than technical.

5. Tominian PVC Pump

The PVC pump in this small town about 40 km east of San was installed in February 1978. Larger than the other two, it uses eleven panels built by Solarex Corp., powering a six-inch Alta-X pump by Guinard. The pump produces 60 cubic meters of water a day without difficulty, but distribution in the town is a problem. There is no water tower next to the pump. Instead, back in 1975 one was installed over a deep well over one kilometer away on the other side of town. While it operated, water was piped from the water tower to eight spigots strategically located in town. But the well went dry after a year. Faced with the fact that the water tower is now next to the wrong well, the Commandant de Cercle had some pipe laid directly from the solar pump into the existing distribution system, while waiting for Mali Aqua Viva or someone to help solve the water tower problem. The solar pump can put water into any one of the town spigots as long as the others are closed, but it cannot pump water up into the distant tower. The temporary solution has been to use a seven-cubic-meter tank truck that is filled daily and that distributes water around town. The truck driver also moves about opening and closing individual spigots during the day as the solar pump maintains water in the system. Aside from the problems with distribution, the only other difficulty of note was a leak around the shaft of the pump which could have been fixed by tightening two bolts but which no one in Tominian seemed to have noticed. As elsewhere, water is provided free to consumers.

6. Planned Solar Pumps

The Delegate of the European Development Fund told the PP team that by 1979, there would be up to 18 solar pumps in Mali. Along with many others, he believes that the low- temperature device of the SOFRETES type has no future unless it is for very large installations of the kind that is now under construction at Diré. The FED is prepared to pay 50% of the cost of solar pumps and up to 75% in exceptional cases. Requests are coming to the FED Delegate from missionaries and lay organizations. He mentioned Timbuktu, Gao, Kayes and Mopti as potential sites. At Bandiagara, Father Joseph Deschamps plans to install a 4-5 kW pump in a 50-60 meter well to supply the local hospital. Likewise at San, a 2-3 kW unit will be placed in the courtyard of the hospital to pump water and possibly to produce electricity for other uses.

TECHNICAL ANALYSIS

1. Solar Energy in Mali

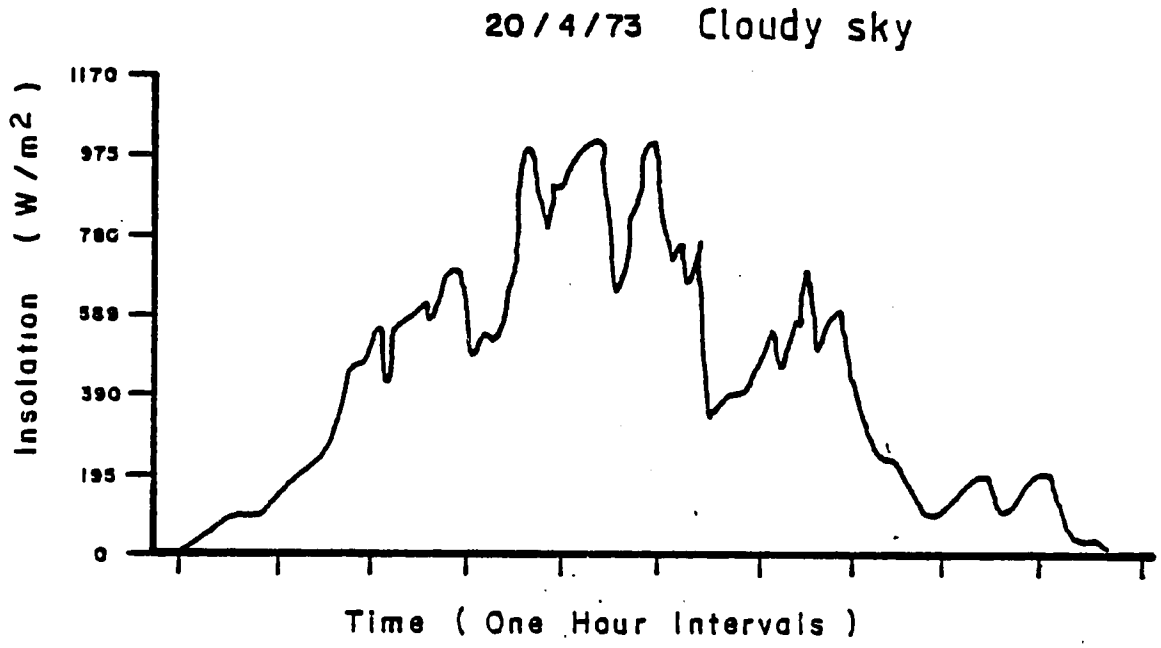
The solar energy resource in Mali is thought to be very large. However, actual measurements are rather scarce.

Two types of data exist. The duration of sunshine (the number of hours of sunshine per day), measured with the Stokes-Campbell heliograph, is recorded at the 18 meteorological stations listed in Appendix H. This is not a very exact measurement since one must arbitrarily decide how bright the sun must be (shining through haze or clouds) before one can count it as sunshine. However, one can use the data to make rough comparisons between sites.

To do quantitative work in solar energy it is necessary to know the solar energy falling on a given area in a given time (called "insolation"). It is usually given as the number of watts per square meter on a horizontal surface. Such insolation measurements were made in Bamako by Touré [TOURE, Ibrahima. Thèse, Docteur de Specialité en Physique, l'Ecole Normale Superieure, Bamako, (1973)] for the period November 1972 to September 1973. Insolation measurements are just now beginning, under WMO/UNDP sponsorship, at four national meteorological stations: Bamako, Tombouctou, San and Kayes. Data from them is not yet available. Examples of Touré's measurements are shown in Fig. B-I.

To calculate the performance of flat-plate or concentrating thermal collectors, the shape of the curve (Fig. B-I) must be known (as well as the air temperature profile). Insolation measurements should be started as soon as possible at he Solar Energy Laboratory so that serious work can be begun on devices using flat plate collectors (hot water heater, dryer).

Photovoltaic converters are less sensitive to the shape of the insolation curve. The amount of electrical energy they can produce is more nearly proportional to the total solar energy received, that is, to the areas under the curves of Fig. B-I. Touré has measured these areas to obtain the total solar energy density received per day. The results, given



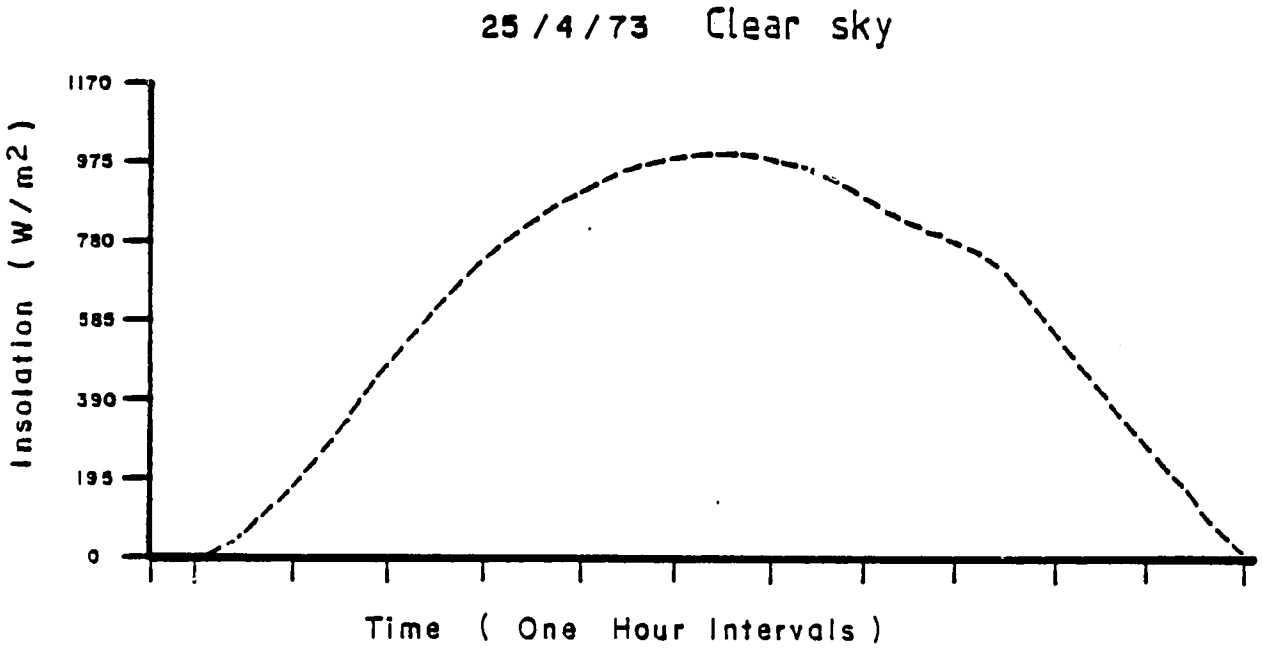


FIGURE B - I : Examples of Insolation at Bamako Measured b Ibrahima Touré.

as averages over 10-day periods, are shown in Table B-1. This table contains all the data on daily solar energy density that the PP team found for Mali. Since it was measured during the drought period, it may be higher than average, at least for the summer months.

TABLE B-1

Total Solar Energy Density

Year and Month	1 to 10	11 to 20	21 to 30	1 to 30	Other Sources
November 1972	-	5.97	4.14	-	
December 1972	4.62	4.38	4.41	4.47	4.65 B
January 1973	4.77	5.13	5.24	5.04	5.14 A
February 1973	5.78	5.62	6.06	5.82	
March 1973	6.31	5.58	6.12	6.00	6.16 B
April 1973	6.70	6.08	6.45	6.41	6.67 A
May 1973	5.75	5.03	5.96	5.58	
June 1973	5.56	5.79	6.22	5.86	5.81 B
July 1973	5.38	5.48	3.08	4.64	6.06 A
August 1973	5.07	4.30	5.85	5.07	
September 1973	5.36	-	-	-	5.81 B
October 1973	-	-	-	-	6.11 A

Total solar energy density received at Bamako in kilowatt hours per square meter per day averaged over 10-day periods.

The last column of Table B-1 shows values obtained from two "world maps" of solar radiation. The values labeled "A" are from Cahiers A.F.E.D.S. No. 1 [Solar Thermal Energy Processes, John Wiley and Sons, N.Y. (1974)], who do not give the stations used, except for Dakar. These world maps are good only for rough estimations.

Solar cells are rated by watts (peak). If a solar panel is rated at 1000 watts (peak), it will produce 1 kW of electrical power at an insolation of 1 kW/m^2, this being chosen as the standard peak value of insolation. Table B-1 gives directly the maximum energy produced by a 1 kW panel. For example, a 1 kW panel will produce 4.62 kilowatt hours of electrical energy

in Bamako each day between December 1 and 10 (on the average). In fact, it will produce somewhat less than this for various subsidiary reasons.

The insolation at Bamako is not exceptionally good. One would expect higher insolation to the north, but the only measurement station is Tamanrasett, 1100 miles to the northeast. The new station at Tombouctou should supply very useful data.

As the solar radiation traverses the atmosphere it is scattered by air molecules, water vapor, dust, water droplets, etc. A receiving station on the ground receives the remaining direct radiation that has penetrated without being scattered and the diffuse radiation which comes from directions other than the sun. Measurements of diffuse radiation are made by shadowing the pyranometer so that it sees all of the sky except for the sun. These measurements have not been made in Mali and they are not part of the WHO/UNDP insolation measurement program. They should be started at the Solar Energy Laboratory.

Examples of direct and diffuse radiation at Dakar are given in Table B-2. The diffuse component exceeds 50% in August. Solar concentrators of high concentration reject most of the diffuse radiation. Thus, a concentrating collector for either solar cells or thermal collection would not produce as much energy as one might think. Concentrating systems were not considered in this program because of the possibility of this diffuse radiation problem and because of potential reliability problems related to reflector surfaces and tracking mechanisms.

TABLE B-2

Percentage of Direct and Diffuse Radiation at Dakar

Month	J	F	M	A	M	J	J	A	S	O	N	D	av.
% of direct radiation	78	76	71	70	73	60	53	46	60	66	67	71	66
% of diffuse radiation	22	24	29	30	27	40	47	54	40	34	33	29	34
Total radiation $1Wh/m^2$ day	5.42/6.07/6.49/6.83/7.01/6.54/5.78/4.74/5.64/5.61/5.03/4.84/5.83												

SOURCE: Institut de Physique Météorologique, University of Dakar

In conclusion, one can say that the solar energy resource is good in the southern part of Mali and that it can be estimated to be excellent in the northern parts of Mali. It is far and away the largest Malian energy resource. Only eleven months' worth of total insolation measurements for one location were found and no measurements of diffuse radiation were found. Measurements of diffuse and total insolation should be started at once in Bamako, and measurements of diffuse insolation should be added to the Kayes, San, Bamako and Tombouctou meteorological stations.

2. Mechanical or Electrical Power from Solar Radiation

Two methods of producing electrical or mechanical power directly from solar radiation are currently in use. They are: (1) Thermodynamic: collecting heat with a flat-plate or concentrating heat collector, then using this heat to drive a thermal engine. An example of the flat-plate type is the SOFRETES* solar water pump installed in many African countries, in Mexico and elsewhere. An example of the concentrating type can be found in a U.S. Department of Energy (DOE) irrigation project in New Mexico. (2) Photovoltaic: conversion of solar radiation directly to electricity by means of the photovoltaic effect in a silicon p-n junction. The Guinard photovoltaic pump installed in Mali, Senegal, Upper Volta and elsewhere is an example of a non-concentrating type. A concentrating photovoltaic pump has been installed by Dow-Corning in New Mexico. Solarex Corporation, under DOE sponsorship, plans to install a 250 kW concentrating photovoltaic system in Arkansas.

Thermodynamic Conversion

The flat-plate thermal engine machines, such as the SOFRETES machine, do not appear to be competitive for village use for the following reasons. Temperatures available from flat plate collectors are too low ($\sim 100^{\circ}C$) to produce high thermodynamic efficiency, especially when it is difficult to obtain a low temperature for the condenser — as it is in the Sahel. As a consequence, a large number of collectors and large heat exchangers are necessary. This entails large support structures. The costs of transporta-

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tion and construction, but mostly the cost of the materials, make the system expensive. The prospects for major cost reductions are poor because of the equation: low temperature collection = large amount of materials. Furthermore, a non-negligible amount of maintenance and repair is needed, some of it requiring skilled people. The SOFRETES pump at Dioila visited by the PP team was undergoing major repairs (all the collectors were disassembled) after operating for only three years. This type of machine is better suited to large installations such as the proposed Bakel and Diré projects in Senegal and in Mali, respectively.

The concentrating thermal type usually employs a parabolic trough reflector to concentrate the solar radiation on a pipe carrying the heat transfer fluid. This allows higher temperatures and, consequently, higher thermodynamic efficiencies to be obtained. It follows that less solar radiation need be collected for the same power, output, the mass of collectors and heat exchangers can be reduced, and ultimately the cost should fall below that of the flat-plate machines. However, a sun-tracking mechanism is required and the high-speed turbines, the system controls, etc. will probably demand a considerable amount of attention from skilled personnel. These systems are in a very early stage of development.

The PP team considers that neither flat plate nor concentrating thermal systems are practical for village installation in connection with this program.

Photovoltaic Conversion

Photovoltaic conversion takes place by direct interaction between a photon of solar radiation and an electron in a semi-conducting material such as silicon. The photon gives the electron enough energy to put it in a higher energy state (across the band-gap), and affairs are so arranged (by means of a p-n junction or a Schottky junction) that the electron has a good chance of returning to its original low-energy state via an external circuit, thus giving up its energy to an external load (battery, motor, light bulb, etc.). It is not a thermodynamic cycle, so high temperatures are not required.

Solar cells are made from very pure single crystals of silicon. Their high cost is a consequence of the cost of pure single crystal silicon and of the many hand operations that are needed during fabrication and assembly. However, the beginning of a mass market, financed by DOE, has already reduced

the price dramatically, and further price decreases of single crystal cells are predicted. Methods of growing silicon by means of continuous pulling from a melt ("edge defined" crystal growth) are being developed to reduce the crystal price while the reduction of fabrication and assembly costs should result from large scale production.

Solar cells have also been made from very thin films of non-crystalline material. Very low ultimate prices can be estimated because of the small amount of material required, the elimination of the need for single crystals, and the automatic processes that can ultimately be used for fabrication. R&D on cadmium sulphide-cuprous sulphide poly-crystalline thin film cells is underway. The best efficiency obtained to date is 5.8% (RCA Laboratories, Princeton, N.J.) which is presently below that required for commercial viability (10-15%). However, theoretical analysis shows that efficiencies above 10% are possible.

The recent record of solar cell prices as well as some predictions are shown in Fig. B-II. The solid lines are "hoped for" prices in 1976 dollars. Future purchases will fall above these lines due to inflation. Some DOE goals are: $2 per peak watt in 1984 by single crystal technology and 30¢ per peak watt by about 1990 by thin film technology.

Solar cells produce direct current at low voltages. This is suitable for driving a pump or grinder directly with only very simple controls. For more general uses such as lighting it will probably be advisable to convert the low voltage direct current to 220 volt, 50 cycle current by use of either a solid state or rotating converter.

As the insolation falling on the panels decreases, because of the hour of the day or because of atmospheric conditions, the power output of the panels decreases. A water pump ceases to pump below this power level and any energy produced by the panel below this power level is wasted. Thus, it would pay to charge batteries during low power conditions and use the stored energy at a later time and at high power levels. The CFAR station at Koni plans to do this with their presently operating solar photovoltaic pump. This is easily possible because only the current from the panels decreases as the insolation decreases, while the voltage stays reasonably high. This very useful property of solar cells is shown in Fig. B-III. Solar cells produce power at low light intensities. This is in sharp contrast to thermal systems which cannot collect heat nor produce mechanical

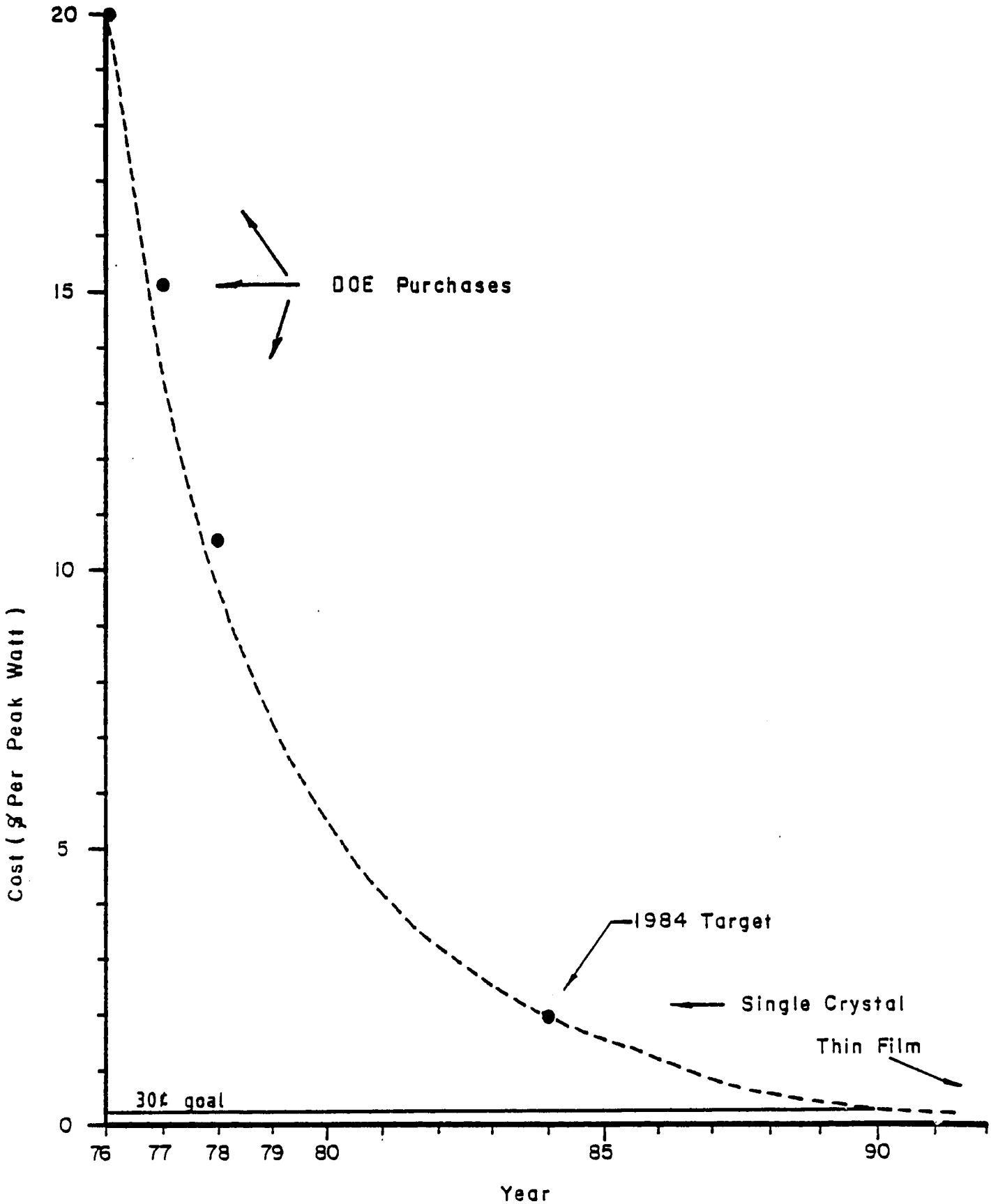
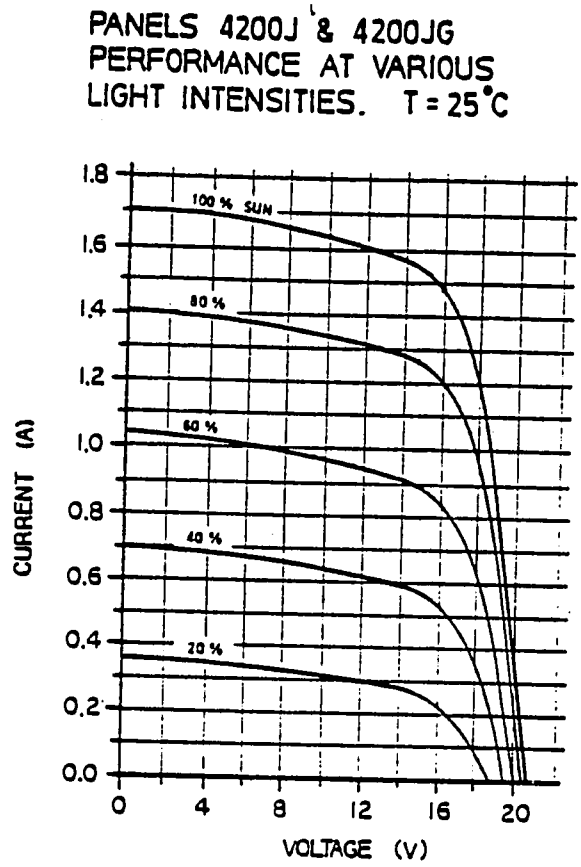


FIGURE B-II : Projected Solar Cell Prices and Some Recent Purchases

Figure B-III



Current-voltage characteristics of solar panels. (SOURCE: Solarex Corporation). These are the panels used at Tominian.

or electrical power below certain light intensities.

Concentrators, usually parabolic or compound parabolic reflectors [see R. Winston, Journal of the Optical Society of America, vol. 60, p. 245 (1970)] are used to increase the light intensity on the solar cells. Thus, fewer solar cells need be used for a given output power requirement. One is making a trade-off between having fewer (expensive) solar cells and more (less expensive) reflector area. This trade-off is thought to be advantageous today; but if the cost of solar cells falls according to DOE projections, it will not be advantageous. Thus, concentrating solar photovoltaic systems should be transitory. As a matter of fact, a recent proposal to USAID to place a concentrating solar photovoltaic pump in Niger quotes a cost, per unit of energy delivered, that is considerably higher than the quotes

which Pompes Guinard is making for installation of non-concentrating photovoltaic pumps in Mali. By taking account of this and of the additional potential sources of maintenance problems, reflectors and sun tracking mechanisms, the PP team has decided to consider only non-concentrating solar photovoltaic systems for use in this program.

3. Distillation

A solar water distiller consists of a box of water covered by a sloping glass. The sun evaporates the water, which condenses on the glass cover and flows down the underside of the glass to a gutter along the bottom edge of the glass. The gutter drains this distilled water into a container. The processes of heat transfer are complex, and much study and experiment has gone into optimizing the operation [see E.D. Howe and B.W. Tleimot, "Twenty Years of Work on Solar Distillation at the University of California," Solar Energy, vol. 16, p. 97, (1974)]. The solar still is reasonably well understood and it is reasonably well optimized, but it costs too much.* The quoted costs in the references below range from $2 to $3 per cubic meter of water. This is competitive for battery water which must be imported into Mali, but it is too expensive for other uses. Since distilled water is not necessarily sterile, it could not be used for medical purposes unless it were sterilized.

Unless Phase II studies uncover village uses justifying this cost, the distiller will not be considered under this program.

4. Solar Cooking

Two types of solar cookers have been suggested. One utilizes a reflector which concentrates light on the cooking pot. It can attain high temperatures but requires suntracking, working in the sun during the hot part of the day, and precarious positioning of the cooking utensil at the focal point of the reflector. The second utilizes a flat-plate, fluid-heating collector from which the fluid can be piped to a stable indoor cooker. However, it must also be used in the middle of the day; the collector should

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*[see above reference and also "Solar Energy" by Langerhorst, et. al., prepared for the Dutch Minister for Development Cooperation, (1977); and see also P.I. Cooper and W.R.W. Read, Solar Energy, vol. 16, p. 1 (1974)]

be positioned several times during the day and, most important, the temperatures are not high enough to cook some traditional dishes.

These reasons may explain why solar cookers have not caught on.

All of these difficulties can be overcome. For example, one can use a high temperature heat transfer fluid and an automatically tracking, concentrating collector. The heat could be stored in an insulated drum of the fluid. One could use the heat at the place, time and temperature desired -- but the cost would be high.

The solar cooker will be considered in this program but in this case it will be a test of people adapting to the technology rather than of adapting the technology to the people. But history has shown that, except for the rat, homosapiens is the most adaptable species.

5. Solar Refrigeration by Means of the Absorption Cycle

This is the cycle used by gas-driven refrigerators. Highly simplified, the process goes like this: liquid ammonia is allowed to escape through an orifice into a low-pressure coil. It evaporates and cools the coil. Since the coil would soon fill with gaseous ammonia and the pressure would rise, it is necessary to absorb the gaseous ammonia in a dilute water-ammonia mixture. Since the water-ammonia mixture soon becomes saturated with ammonia and ceases to absorb more ammonia, it is necessary to boil off the ammonia by heating the mixture. Solar energy can be used to supply the heat. The dilute mixture is then sent back to absorb more ammonia while the gaseous hot ammonia that had been boiled off is cooled, condensed and sent back to the original liquid ammonia container, thus completing the cycle.

Such solar refrigerators have no moving parts and if well constructed will be trouble free and have a very long life. However, they are expensive. They require a high temperature flat-plate collector capable of producing temperatures of about 100° C. No commercial solar units of village size are on the market, although there are lithium bromide-water units commercially available. The latter are for air conditioning and cannot reach temperatures low enough for refrigeration. Development of a suitable unit in Mali is difficult because of the relatively high technology required.

Direct solar refrigeration by means of the absorption cycle will not be considered for this program unless an economical commercial unit becomes

available before the start of Phase III.

6. The Dryer

The construction of a dryer is quite simple. It consists of a solar collector which heats air to 50-60° C. This air flows by thermal means into a box in which the product to be dried is placed on wire shelves or hung from hooks. A chimney on top of the box augments the thermal syphoning of hot air through the box. The collector is usually tilted to assist the flow of warm air. Climate is another determinant of the optimum tilt angle, and this determinant is not always consistant with the air flow requirement. The temperature and humidity of the outside air, and the optimum temperature for each stage of drying - there are 3 stages in the drying of fish for example - all affect the efficiency of the process and the quality of the dried product. These variables are mentioned in order to point out that a large amount of practice is necessary in order to dry a product efficiently and to get the quality desired.

The cost of a dryer of the type and size built at the Solar Energy Laboratory is between $100 and $300. It is not a large dryer. The amount of dried product it can produce per day and the value of the dried product to a villager are not known. These are things which must be determined in Phase II. It is worth remarking that traditional methods of drying - by laying the product on a rack in the sun - are very cheap and quite efficient during the dry season. Fish drying is an exception in that as much as 50% of the fish is lost to insects during the traditional drying process. The temperatures produced by the solar dryer are too high for these insects to live and consequently this loss is eliminated. Wood or dung fires may be used to assist the drying process. Solar drying would reduce such fuel consumption.

The dryer has been chosen as one of the devices to be tried in villages. However, Phases I and II must find answers to the foregoing questions and determine the cost of the unit, amount of produce dried in given time periods, operation variables, and the value of the dried produce to villagers.

7. Wind Energy in Mali

The wind in Mali is not a large energy resource. In general, wind velocities in the southern part of Mali are too low to be useful. The wind speeds in the northern regions -- Gao, Tombouctou, Tessalit, etc. -- appear to be marginally to reasonably useful but careful wind speed measurements should be made before windmills are installed. The wind energy resource is in inverse relation to the population density; the wind velocities are too low where most of the people live (south) and they appear to be high enough only where very few people live (north).

Average wind speeds are given by Giri and Meunier [Evaluation des Energies Nouvelles pour le Développement des Etats Africaines, SEMA, Montrouge, France (1977), p. 304] and by Howe and Staff [Energy for the Villages of Africa, Overseas Development Council, Wash., D.C. (1977), p. 106]. Their wind speed maps show average wind speeds of 1 to 3 m/sec in southern Mali, about 4 m/sec at Gao and about 5 m/sec at Tessalit.

Very approximately, wind speeds below 4 m/s (9 mph) are not useful. Jim Sencenbaugh, of Sencenbaugh Wind Electric, Palo Alto, CA, puts the cut-off speed at 4.5 m/s (10 mph).

Curves of the electrical output of three commercial wind machines are shown in Fig. B-IV. The rapid decrease of electric power output at low wind speeds is a consequence mainly of the speed cubed law of wind power production. It is evident that wind speeds below 5 m/s are not very useful.

As a consequence, the distribution of wind speeds must be known. Such distributions are given by Koné [KONE, Kassoum, "Production d'Energie Eolienne du Mali en vue de l'Electrification du Village de Post-Cure de Samanko." Projet de fin d'Etude, Ecole Nationale d'Ingenieurs du Mali, Bamako (1975)] who analyzed a large amount of data obtained from the Service Météorologique du Mali in Bamako. One can get a good idea of the viability of a windmill by reading from Koné's data the number of hours per day during which the wind speed is above 5 m/s. This data is given in Table B-3 for four cities in Mali. One can see immediately that one must go north, and perhaps east, in order to find good wind power territory. When one realizes that much of the wind comes in storms when the windmill must be shut off to avoid damage, the prospects for viable wind power in Mali, except for the north, become dim indeed.

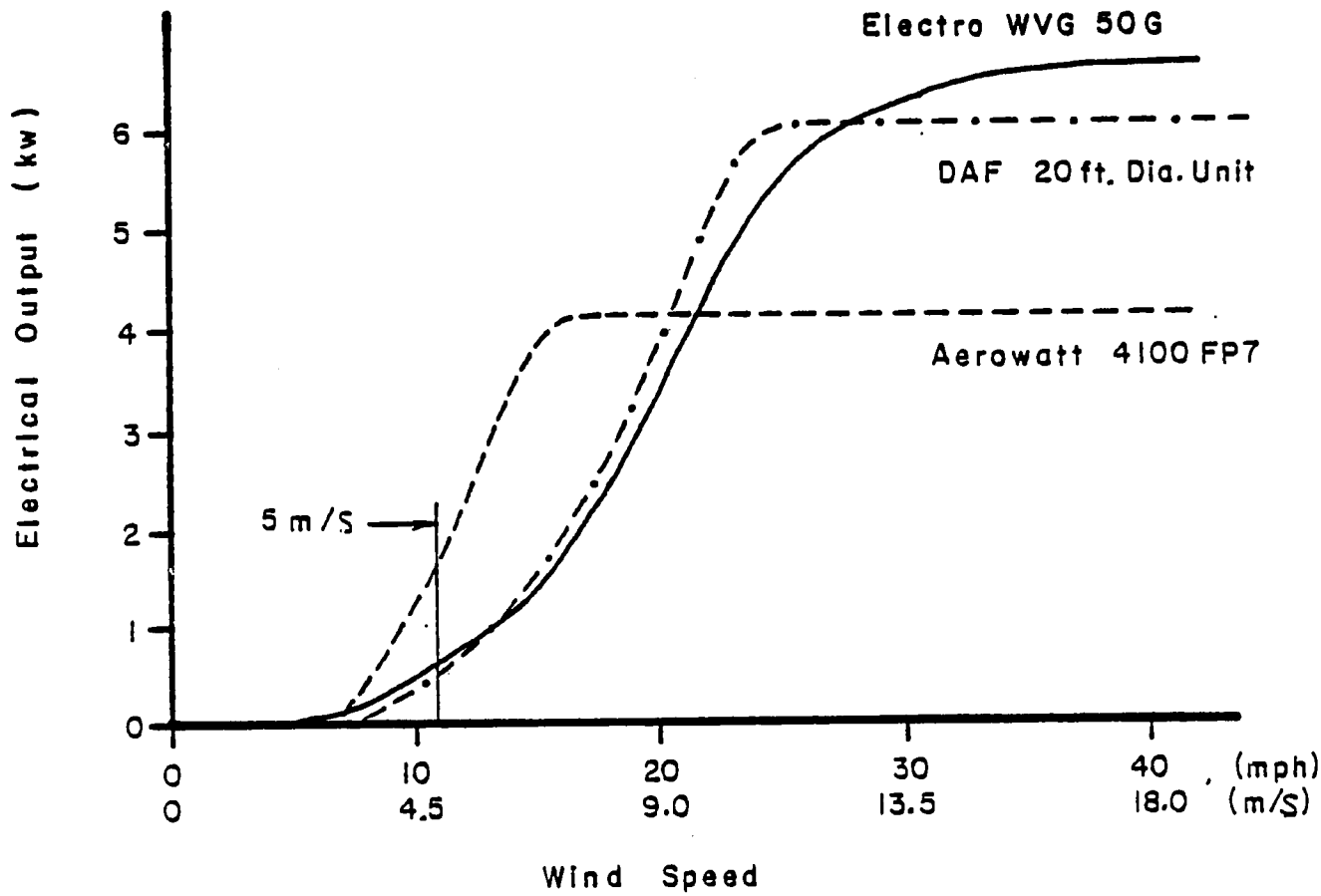

FIGURE B-IV: Electrical Output Versus Wind Speed for Three Commercial Wind Electric Machines. Wind Speeds Below 4 m/s are Not Very Useful. From Higgen, et al, Proceedings of the International Solar Energy Society, Aug. 1976 at Winnipeg, Vol. 7, Page 184.

TABLE B-3

Hours Per Day With Wind Above 5 m/s

Month	Average number of hours per day during which the wind speed is greater than 5 m/s			
	Bamako	Kayes	Mopti	Gao
Jan.	1.42	2.52	4.66	10.10
Feb.	1.20	1.10	2.18	5.93
Mar.	2.91	0.17	2.45	6.87
Apr.	4.18	1.36	3.28	9.19
May	1.96	2.34	1.91	5.91
June	1.14	5.53	3.86	8.44
July	0.35	5.88	3.74	9.08
Aug.	0.00	3.20	1.06	4.76
Sept.	0.72	0.40	1.07	5.52
Oct.	0.00	0.31	0.75	2.18
Nov.	0.95	0.07	1.73	7.50
Dec.	1.23	0.57	3.00	10.01
Mean	1.34 hrs	1.96 hrs	2.48 hrs	7.92 hrs

Calculations of the maximum amount of energy available from wind accounting for the entire wind speed distribution have been made by Argand [André Argand, Mésure des Paramétres Caractéristiques de l'Energie Eolienne etc. Proceedings of the United Nations Conference on New Sources of Energy (1961), volume 7, p. 21]. He finds the amount of energy theoretically available to be:

Kayes	15 kwh per m^2 per year
Koulouba	100 kwh per m^2 per year
Mopti	300 kwh per m^2 per year
Mauritania	2000 (average) kwh per m^2 per year
France	3000 (good site) kwh per m^2 per year

The southern regions of Mali have very little wind energy available as compared with sea coast and temperate zone countries.

In spite of this, windmills have been installed throughout southern Mali in the past. They have always failed. The CFAR station at Koni had a Savonius rotor for two years, but took it out four months ago because "there wasn't enough wind" [Frère Desrosiers, CFAR Koni]. Koni is near the Doukouloumba Forest site where windmills were suggested in the PID. The PP team does not recommend installing windmills there.

The well-remembered Gao water-pumping windmills also failed. Thirty-five were installed between 1956 and 1958, and three more in 1960-1961. Their locations were:

Gao	18
Bandiagara-Douenza	7
Tombouctou	3
Goundam	2
Macina	3
Nioro-Nara	3
Bamako	2

By 1959 none of the initial 35 windmills was working. A contract was signed with a European organization, ELAF, for maintenance on the Aermotor windmills. The few CAME windmills were apparently abandoned. The restored windmills worked up to 1962, when maintenance duties were transferred to a Malian maintenance crew. Within a few years none of the windmills was working.

Apparently the breakdowns resulted from lack of spare parts and poor maintenance. However, the wind is too low at some locations to give satisfactory performance and it may also be that the Gao wind measurements are not correct that actual wind speeds are lower than reported, and that the windmills just did not pump sufficient water to be worthwhile. Under the Renewable Energy Project an attempt will be made to find out what went wrong, and to successfully reintroduce water pumping windmills into northern areas.

In addition, the people at the Ecole d'Ingenieurs will work on windmill concepts that should work better at low wind speeds. (This could include Kassoum KONE who now works in a furniture factory.) Such a windmill could be installed in the Nioro and Nara areas.

The primary use for windmills is water pumping. Electricity generation and grinding of cereals are not as essential and would require the storage of electricity in batteries. Water pumping windmills for winds above 5 m/s are well proven and can be purchased from established manufacturers.

8. Small Hydropower

The opportunities for hydropower installations of village size in Mali appear to be very limited. The concentration of rains in the monsoon period from May to October with a peak in August and very high evaporation rates during the hot, dry months combine to make many water courses seasonal. Small rivers that run all year are still too large for village use while a stream that is small enough is dry most of the year.

The Bureau d'Etudes of the Direction Nationale de l'Hydraulique has provided information on five small dams on the Dogon plateau, summarized in Table B-4 below. These dams hold water well into the dry season. They are usually opened in April and not closed again until late September. They cannot produce power. A larger dam is planned at Lougourougoumbou, 30 km from Bandiagara, which will have a 15 meter head and store 6,100,000 cubic meters of water. The plan is to produce electrical power since it will contain water throughout the year, but no study of generating capacity has yet been done. Such a project is far larger than village size.

TABLE B-4

Small Dams, Dogon Plateau

Site	Sibi-Sibi I	Somoli	Nombo	Sogodougou	Djoundjourou
Length (meters)	70	159	38	276	387
Height (meters)	3.6	6.5	6	3.4	6.2
Surface (km^2)	55	100	4	1,100	250
Capacity (000 m^3)	40	800	18	120	250
Irrigable (ha.) area	12	30	2	25	25

The Bureau d'Etudes was unable to provide any information on potential water courses in southern Mali. The Hydrology Division has made available the following list of permanent small streams. The PP team was not able to obtain more information about them, but it is doubtful that any would provide the drop required for a hydropower installation.

Name of Stream	Tributary of	Name of Stream	Tributary of
Dlaninn	Niger	Bafini	Bagoé
Faya	"	Loufon	"
Banifing I	Baoulé	Lotio	Banifing 4
Koba	Niger	Dla	Baoulé
Mono	Baoulé	Badinn-Ko	"
NTemou	"	Tali-Ko	"
Banifing II	"	Balé	Bafing
Dégou	"	Konaga	Bakoye
Koba	Bagoé	Kêtiou	Sénégal
Banifing 3	"	Balinn	Bafing
Niénié	"	Darouma	Bakoye
Mani	"	Doundi	Falémé
Koba	"	Bilaliko	"
Dekorobougou	"	Kérékoto	"
Kobi	"	Souyaka	Bakoye

Unless new information becomes available, the PP team concluded that village-size hydropower opportunities in Mali are too limited to consider further.

9. Bio-gas Production

The bio-gas generation process utilizes bacteria, digesting organic matter in the absence of air, to produce methane by the following formula: cellulose materials plus water → methane plus carbon dioxide plus sludge. The organic material, such as cow manure, is mixed with water and put in an air-tight container. Initially, acid-forming bacteria will break down the organic matter and produce volatile fatty acids. The acidity will increase. After a few weeks the methane-producing bacterial will begin to work and the acidity will decrease. The temperature should be maintained at 37° C as closely as possible since this is the optimum temperature for the methane-producing bacteria. The production of methane will rise to a maximum after several months and finally fall again as the store of organic matter becomes completely degraded. The resulting gas will be about 60% methane, 30% carbon dioxide and less than 10% of other gases. It has a heat content of about 650 BTU/ft^3 of about 5,500 k cal/m^3. This is about

60% of the value for the natural gas that is sold in the U.S.

The remaining sludge, which is a liquid slurry compound mostly of dead bacteria, contains most of the nitrogen and other nutrients that the original manure contained. Thus one ends up with the energy plus the fertilizer in contrast to the pyrolysis process in which the fertilizer goes up the chimney. In addition, there is sediment at the bottom and scum at the top. This must be removed. The description above is of a batch process. The whole process can also be done continuously by feeding in the manure in measured quantities each day and removing the products -- gas, sludge, sediment and scum.

A wide variety of batch and continuous bio-digesters have been used. They all require a considerable amount of care and maintenance. If the manure is fed into a continuous digester too rapidly, the acidity will increase and the methane-producing bacteria will die. Then one must reduce the feeding rate until the acidity decreases. The sludge, as a liquid slurry, must be carried in containers to the fields as liquid fertilizer. The scum and sediment must be removed.

The gas can be stored but storage is not simple. About one day's gas production can be stored in the top of the digesting container if one uses a tank expanding on a liquid air seal (no air is allowed in the tank). Liquification of the gas by compression, as is done for propane or butane, is out of the question in village use. It is best to use the gas immediately.

This process requires a large amount of water -- about 1 cubic meter for each 10-30 cubic meters of gas produced. Since Mali is a dry country, a process using little water may be desirable. One method has been suggested by Kinsey (Resources Technology Corporation, San Jose, CA) and apparently developed in France during World War II. In this process the organic material, for example a mixture of cow dung and agricultural wastes, is moistened and put in a container which is initially open to the air. Aerobic fermentation takes place, heating the material. Air is then prevented from entering and an anaerobic fermentation takes place, producing methane. Again the temperature should be near 37° C. This may be attained by allowing a controlled amount of aerobic digestion which produces heat. In addition to using less water this process produces a compost which should be easier to carry and distribute as fertilizer.

Development of such "moist" digesters has not been widespread. However, it works as is evident by the "mining" of gas from city dumps in the U.S. Gas is produced commercially by drilling into old city dumps. The gas is mixed with high quality natural gas to produce a 1000 BTU/ft^3 gas and piped directly into gas distribution lines.

10. Pyrolysis of Vegetable Matter

Pyrolysis is simply the conversion of a form of energy, vegetable matter, to another form such as charcoal, oil or gas. The basic source of energy remains sunshine; and water, carbon dioxide and nutrients from the soil, e.g. wood, peanut shells, rice straw, etc. Pyrolysis is the conversion of these products by heating, in the complete or partial absence of air, so that gaseous, liquid, or solid combustible products are obtained.

The only simple pyrolysis process presently used is the manufacture of charcoal.

Pyrolysis processes for producing char, oil and gas from other agricultural wastes such as peanut shells are complex, expensive and not presently developed to a state suitable for village use. Resources Technology Corporation of San Jose, CA has cooperated in a study for solid waste pyrolysis in Los Angeles county and found that a 1000 ton per day (mostly paper) plant will cost 50 to 80 million dollars. Therefore a plant scaled down to 1 ton/day for village use would cost at least $50,000 to $80,000 and produce about 6 million kilojoules of energy per day. This is the energy content of about 300 kg of wood. It should be noted that the gas produced by a pyrolysis plant cannot be easily stored or transported. It should be used as it is produced since a large part of its energy exists as sensible heat (it comes out of the reactor at a high temperature.) A smaller pyrolysis unit is being developed by Georgia Institute of Technology for use in Ghana, but it appears to be too large and complex for village operation.

The villages visited by the PP team did not have appreciable agricultural waste resources, although Roland Hainer, manager of the new SEPAMA peanut oil mill at Kita reported that some villages did an appreciable amount of peanut decortication. Both the Kita peanut oil plant and the Chinese tea operation at Sikasso, for example, already burn their by-products

to produce electrical power for their operations.*

In conclusion, except for charcoal production, pyrolysis at the village level does not appear promising in Mali at this time. An exception is the production of charcoal. More efficient charcoal production methods will be considered in connection with better woodburning and charcoal-burning stoves.

11. Woodburning Stoves

In an ordinary wood cooking fire, such as one sees in rural Mali, a large amount of unburned fuel and a large amount of heat by-passes the objects that are to be heated. The unburned fuel is in the form of particles of carbonaceous material (smoke) and unburned gases. The corrective measure is introduction of sufficient oxygen or reduction of the burning rate to correspond to complete oxidation of the fuel. This requires a controlled oxygen feed and a controlled burning rate. In order to reduce the heat that by-passes the object to be heated, it is necessary to arrange the stove and cooking utensil so that heat is transferred efficiently to the cooking utensil. Thus, the objectives to be attained in an efficient cooking stove are (1) complete combustion of the fuel and (2) efficient transfer of heat to the object being cooked.

The large fireplace - like the grills that one sees at Dioila, for example, satisfies the first requirement fairly well. The wood is fed in slowly so that the burning rate is controlled. There is a hot bed of coals which promotes good combustion of the gases and carbonaceous particles (the amount of unburned fuel should be measured however), and there is no smoke, which is an indicator of combustion efficiency (smoke = unburned particles of fuel). However, the transfer of heat to the object being cooked is very poor. There is a large iron grill on which a few utensils, pieces of meat, etc. are placed and most of the heat bypasses them.

One must investigate wood burning methods in some detail to see where the inefficiencies are; either incomplete burning or poor heat transfer to the object being cooked could be reasons. Corrective action should then be

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*Guy Belloncle, a well-known French sociologist specializing in African rural development, maintains that recent experiments to improve soil fertility by plowing under peanut shells in Senegal have produced 30% higher crop yields. He considers this to be a much more valid use of shells by villagers.

taken. Stoves that satisfy both complete combustion and efficient heat transfer need to be designed, preferably with materials available in Mali. If possible, the design should be compatible with normal cooking customs and habits.

The work to be undertaken in this program will be (a) investigation of the completeness of combustion and of the efficiency of heat transfer in traditional cooking and water heating practice, (b) improvements of these methods and (c) introduction of cost-effective equipment, using local materials and construction capabilities as much as possible, which efficiently transfer heat to the object being cooked and promote complete combustion of the wood.

12. Water Heating

Solar water heaters for village use consist of a flat-plate solar collector and a water tank. The tank would be filled in the morning, the water would heat during the day, and it could be used in the evening and in the morning. The tank would then be refilled. A diagram of such a water heater is shown in Fig. B-V. It would be refilled by bucket.

This is almost identical to the water heater currently produced by the Solar Energy Laboratory. It is important to instruct the user to use clean water, to fill the tank in the morning, to fill it above the inlet pipe level, and to carefully replace the insulating cover.

13. Water Sterilization

Water sterilizing can be done with the water heater described in the section above on water heating provided that the low temperature (60 C) collector is replaced by a high temperature (100 C) collector. The high temperature collector must have either a selectively-coated absorber plate or double glazing. Additional insulation must be added to the tank. To sterilize the water, it must be held at a temperature near the boiling point for a suitable time.

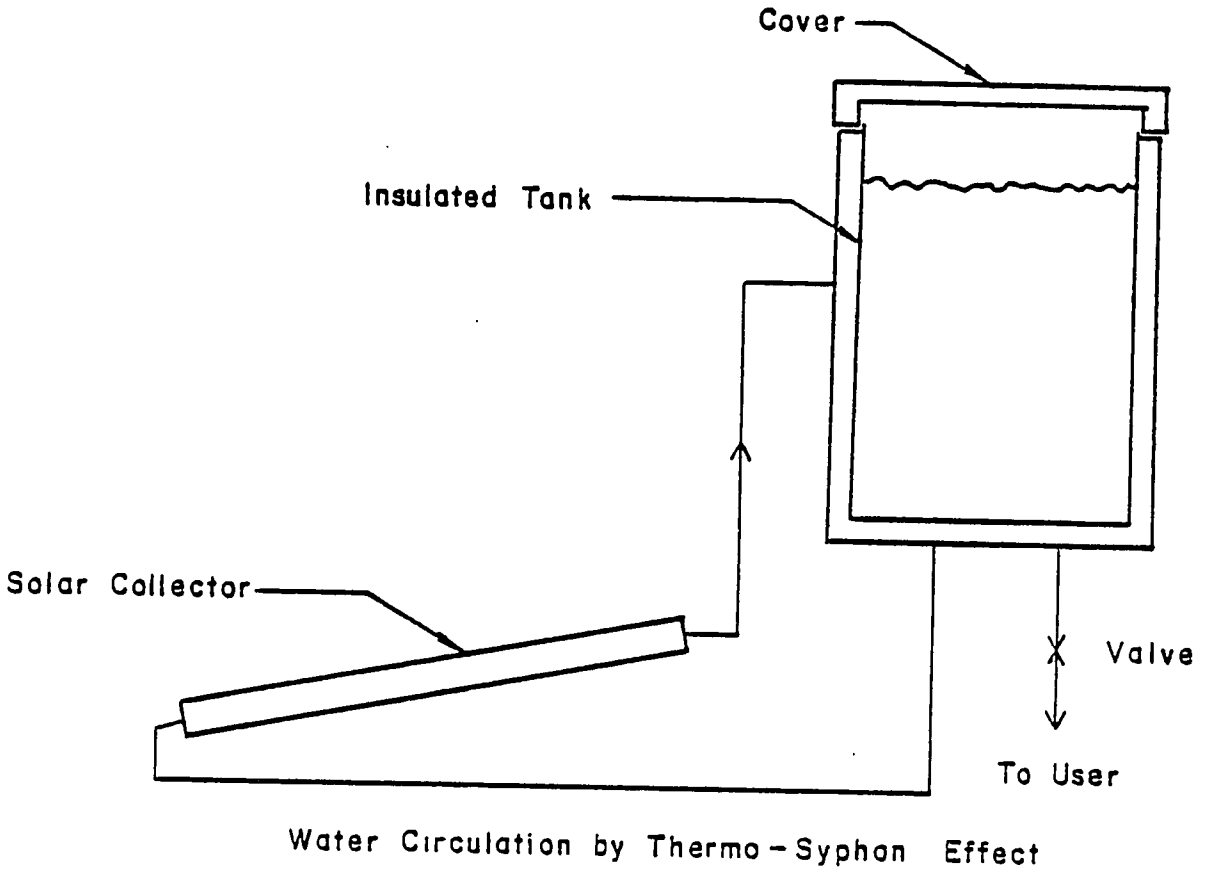


FIGURE B-V: Diagram of Hot Water Heater for Village Use.

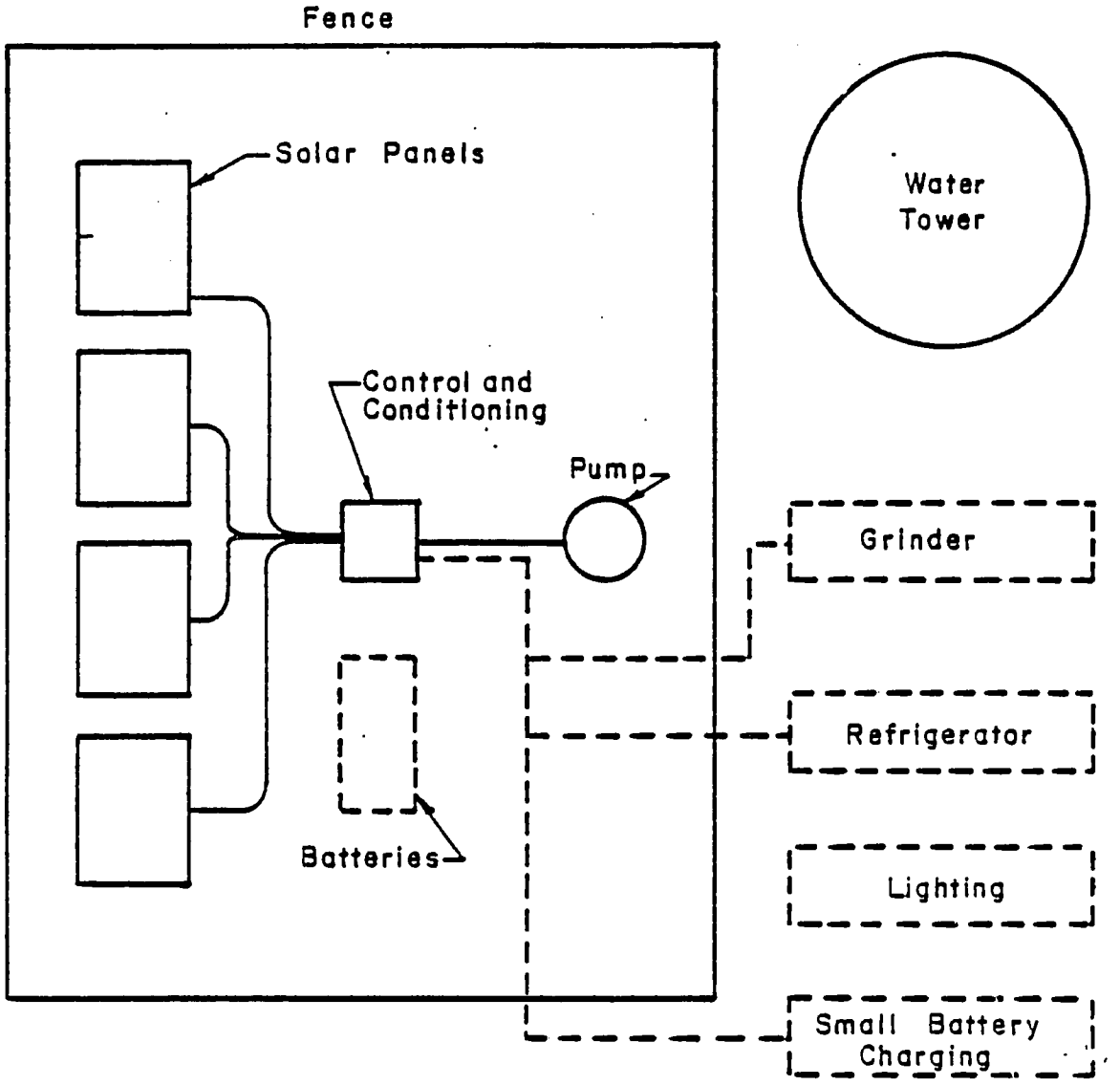


FIGURE B-VI: Diagram of a Solar Photovoltaic Water Pump System - Shown by Solid Lines. Electrical Storage Can Be Added and the Electrical Power Can Be Used For Other Functions - Broken Lines.

SOCIAL SOUNDNESS ANALYSIS

Sociocultural Feasibility

The project is designed to maximize reliance upon indigenous Malian institutions in every phase of its development. First, the anthropologist designated to serve as a consultant to the project from its inception will have as his or her immediate task the preparation of a survey of the existing and very considerable ethnographic literature on rural Malian society. This survey will be used to prepare a series of sociocultural profiles on the peoples to be affected by the project in its first three phases. These are the Bambara, the Peuhl, the Maure, the Sarakollé, and the Sonrai. In developing these ethnographic profiles his or her focus should be upon those fundamental societal institutions at the rural level that appear to have most bearing on the project's outcome: patterns of subsistence technology, economic systems, forms of social and political organization, and religious beliefs and practices which sanction the existing institutional order. Armed with this essential background information he or she will be able more readily to identify those aspects of traditional rural life which may either facilitate or impede the technological innovations proposed for a later phase of the project.

In this preliminary endeavor he or she should call upon as consultants the several competent Malian sociologists and ethnologists presently at work under the aegis of various government organizations. Those brought into a consultative role to the project should be of the calibre of Kary Dembélé, sociologist at the Institut de Productivité et de Gestion Prévisionnelle (IPGP); Bernard Cissoko, sociologist at the Ecole Normale Supérieure; Alfa Konaré, ethnologist and new Minister of Youth, Sport, Arts and Culture; Béléfeng Sako, ethnologist at the Société Malienne d'Exploitation des Ressources Touristiques; and the sociologists and ethnologists associated with the Patrimoine Historique et Ethnographique, the Office Malien du Bétail et de la Viande (OMBEVI), and the Direction Nationale de l'Alphabetisation Fonctionnelle et de la Linguistique Appliquée. Contact with local scholars such as these will assure both that the project anthropologist is aware of current in-country research of possible relevance to the project and that the Malian social science community has an opportunity to benefit from Project research efforts and results.

At the same initial stage and to achieve the same objective, a working research library should be set up for the project and provided with copies of the appropriate ethnographic literature on rural Malian culture. At the conclusion of the project whatever background documents have been acquired along with a record of research findings should be turned over to the library of the Malian institution determined by the project anthropologist to be the most appropriate and secure repository. AID/Mali should develop an on-going interest in such a collection as a research facility of value for future projects.

The purpose of this collaborative approach is to build upon existing Malian "institutional strengths" in the two senses of that phase: by identifying and utilizing both indigenous structures and modern Malian organizations in the achievement of project goals.

In accordance with this objective, an ethnographic survey of all peoples to be affected by the project is planned to begin in the latter part of the project's first phase, to continue with fieldwork during the second phase, with testing during its third phase, and to conclude during phase four with an evaluation of the future role of autocthonous institutions in the further development of Mali's renewable energy resources. Because rural Malian society has already been the object of several decades of distinguished anthropological study, a number of fundamental questions about the social feasibility of the project can be answered even before it is begun.

Who Lives Where?

The majority of the predominantly rural population that will ultimately be affected by the project is comprised of farmers who live in the southern and central portions of the country. In the south full-time sedentary cultivators predominate. A numerically smaller populace to be affected live in the Sahelian zone, where farming is usually combined with some measure of reliance on livestock raising to provide the subsistence base. Further to the north, as soils become poorer and rainfall is more scarce and uncertain, herding becomes the dominant means of making a living. In the desert only pastoral nomadism is possible. Herdsmen are sparsely scattered along the southern fringe of the Sahara. The interior desert is almost unpopulated.

The Mande-speaking peoples, all of whom are sedentary cultivators, comprise Mali's largest single ethnic group. The Bambara, speakers of the Mande language, Bamanan kan, are numerically most important. They number about two million and live throughout south-central Mali, from the border with the Ivory Coast in the south almost to Nioro in the northwest, to Mopti in the northeast, and to San and Koutiala in the east. Next in population size are the closely related million or more Malinké (or Maninka) who live to the west of the Bambara, along the border with Senegal and Guinea from Bafoulabé in the north to Yanfolila in the south.

To the northwest, along the Mauritanian frontier from Kayes to Nara, lives a smaller population of Sarakollé (or Soninké). They number about 500,000. To the east and north are the Dogon (or Hambé), a Voltaic people with a population of about 250,000, and the Sonrai (or Songhay) who live still further to the north and east, from Goundam and Tombouctou to Gao and the border with Niger. A fishing people, the Bobo, live along the Bani and Niger rivers. There are also smaller populations of Sénoufo, Diawara, Bozo, and Khassonké.

The herding peoples of the southern and central parts of Mali are mostly Peul (Fulani). To the northeast along the edges of the desert are found smaller populations of Maure and Taureg, linguistically related pastoral nomadic peoples with strong affinities with Mauritanian herding peoples of Berber origin.

The Mande-speaking peoples of Mali, the majority of whom are Bambara, are shifting cultivators of millet and sorghum. Living among them for at least part of the year are nomadic Peul who care for a portion of the farmers' livestock in exchange for access to pasturage and watering places during the dry season. When the rains begin and the farmers must prepare their fields for planting, the Peul move off with their animals to the north. Since the drought a growing number of Peul have abandoned pastoralism for farming. Some Maure, actually the descendants of the Maure's former slaves, are also sedentary. However, most remain fully nomadic.

How Are They Organized?

Despite a variety of specific institutional differences, the basic structure of rural society throughout Mali exhibits a greater and more

significant number of institutional similarities. Among every rural Malian people property is held and work is organized on the basis of kinship. The representative unit of production is the domestic group comprised of a core of adult men descended through the male line from a common male ancestor. The patrilineal household is typically comprised of the separate dwellings of a man and his wife or wives, his married sons and their wives and children, and his own unmarried daughters.

Typically each patrilocal extended family is located near others to which its core members are related by a bond of shared agnatic descent. Because all lineages are to some extent exogamous (a preference now tempered by the Moslem practice of patrilateral parallel cousin marriage) most are necessarily related to neighboring domestic groups through marriage. The resulting network of alliances based on affinity provides for the allocation of most productive goods: farmland, tools, food processing equipment, and storage facilities; for the organization of work and for the distribution of most of what is produced. Reciprocity is strongly sanctioned within the family. Among almost all farmers a portion of the harvest is held in the granaries of the extended family head and allocated to family members in need. The family herds of Malian pastoral nomads serve similarly as a source of material security for the entire localized membership of the kin group.

In addition to heavy reliance on the production of subsistence crops, mostly food grains which are consumed by the family units which produce them, other goods are produced for market sale: garden crops and the results of dry season specialization in a variety of crafts, many of which are the prerogative of occupational castes: leather workers, carpenters, blacksmiths, weavers, and others.

The societies of both Malian farmers and herders are stratified. Persons of free ancestry (Horon in Bambara) generally monopolize positions at the apex of the status hierarchy, the richest and "noblest" among them having the highest standing. Figuratively more to the side than below this latter category, are casted groups of artisans (Nyamakala in Bambara), whose social position is more clearly separate than inferior. Patently at the bottom of the status hierarchy are the slaves (Dyon in Bambara) and, in the north of the country, people whose economic dependency upon their

subordinate status of females is always specifically determined by their relationship to males.

Associations are widespread in rural Mali. Most are based on age. The ton of the Bambara is representative. Comprised of male and female sectors, it includes all young persons of the same generation. Organized to work together collectively, association members pool the money they earn in the fields to hold dances or buy clothing or medicine. They also function as rotating credit associations. Other associations take the form of joking alliances (senenkounia in Bambara) between lineages or ethnic groups. All such groupings cut across kinship ties and class and caste barriers to form an often community-wide network of reciprocal relations that greatly extend the individual's field of socioeconomic security and add useful flexibility to the social system.

The indigenous authority systems typical of rural Mali invariably derive their structure from the patriarchal lineage organization. The eldest male members of the local lineages of free descent hold the right to political power. Generally the senior members of the lineages that comprise a local farming community or group of herders serve as counselors to the eldest responsible male member of the founding lineage of the local community. He is the chief and passes his decision-making power on to his younger brother or eldest son.

At each level of the social structure the right to the exercise of power over subordinates is reinforced both by the control over their access to productive goods, to land and/or pasturage, and by belief in the spirits of the ancestors of the kin group. Those who disobey the edicts of the elders, who are their ancestors' closest descendants, risk serious supernatural punishment. The threatened withdrawal of vital economic support is a control of equal weight.

This belief in the potent spirits of the ancestors, and in a variety of sources of supernatural power derived from the forces of nature — the sky, the earth, and the rains — is complemented by the widespread espousal of Islam. The Moslem religion provides a valuable basis for organizing people across ethnic lines and is generally a powerful source of economic, social, and political conservatism throughout Mali. The marabouts, Moslem religious leaders, must be seriously reckoned with in implementing any sort of program directed toward the rural sector.

Allocation of Time

During the rainy season all able-bodied members of the sedentary population are engaged nearly fulltime in food production. The fields are cleared for planting in early spring and planting and cultivation keeps men, women, and young people steadily on the land until the fall harvest which lasts from September to December. In addition to their work in the fields, women are responsible for gathering firewood and water, for processing food and preparing meals, for washing and cleaning, and for child care. With the possible exception of the favored wives of a few high-status men, the Malian woman's workload is generally heavier than that of her male counterpart. A particularly attractive feature of this project is that many of the tasks that could be alleviated through the application of solar energy traditionally are women's work.

In the dry season, which lasts from late fall to late spring, labor is less intensive. For those who remain at home, this time is devoted to the repair of tools, weapons, and other household goods, and to craft specialization. In accordance with a tradition that is now more than a half century old, many young men leave home after the harvest to seek work in urban areas and on plantations, especially those of the Ivory Coast. Young men from the northeast, especially among the Sarakollé, go to Senegal and to France in great numbers. Money earned from migrant labor constitutes an important source of cash income for the entire family. A part of the cash thus earned is also used to buy the presents needed by a young man in order to acquire a wife and to establish his own household. The value of money earned from this migratory labor must be balanced off against the loss to the migrants' home communities, and to Mali as a whole, of the output of this part of the labor force during its most vigorous years.

Renewable Energy Project: Motivation

The probable motivation of potential participants in this project has to be examined at several levels. Among the poorest of rural farmers and herders, interest in the project's benefits will arise from their desire for some measure of relief from particularly arduous tasks.

Sustaining an adequate water supply is the most dramatic example. Like most women in rural Mali, the girls and women of Demba Diawara and Dilly, two of the sites selected for early project starts, spend several hours a day at this occupation.

The wellbeing of livestock is also dependent upon a fragile water supply. The limited availability of water curtails gardening efforts as well. For women particularly the provision of a more adequate and readily accessible water supply would ease their current workload and provide them with the additional time — and the additional water — necessary to increase the gardening activities which are an important source of women's personal income. Some of the village women's freed time would undoubtedly be directed to farmwork. Because the product of their labor in the fields is controlled by their husbands, it is by no means certain that women would welcome this switch. Therefore, an important element to assess during the survey and testing phases of the project will be the extent to which women have the liberty to reallocate released time to alternative tasks of their own choosing and/or from which they can be certain to derive personal material benefit. Presumably some freed time will also be redirected to childcare and household tasks.

The labor time thus reallocated has the potential for benefiting the entire community by improving the quality of child care and by raising the standard of household cleanliness, actions essential to the reduction of disease and the amelioration of community life. It will be critical to monitor this potential shift in the allocation of women's labor. Food-drying facilities seem certain to find acceptance with a minimum of resistance. They will demonstrably increase food processing efficiency without having any foreseeable deleterious side effects. The labor time they save is already under women's control. The same would be true of the labor time saved by the introduction of cereal grinders. If it can be ascertained that women in all groups retain the right to reallocate the time saved by the new devices, women would appear to be highly motivated to accept them. The already wide acceptance of conventional cereal grinders suggests strongly that solar-energized machines will also be accepted. To the extent that their operation is less costly, they are likely to be preferred.

A second level at which motivation must be examined related to the intermediate role of locally-trained village level cadre who would take an initially critical part in the installation and maintenance of whatever solar energy devices are installed. People will be motivated to seek such positions because of the enhanced social standing they offer.

The money paid to such persons by the community must be adequate to maintain them at an acceptable level so that they can be expected to give their energies fully to their work without seeking subsidiary remuneration from the rural inhabitants.

It is imperative that such alienating abuses be avoided by the project during all phases of its development. If monetary limitations are absolute, then job performance expectations will have to be adjusted accordingly. During the testing phase, the field supervisors will have to control rigorously for this, and a means of avoiding it when solar devices are more widely installed should be explicitly identified in the final project evaluation.

This same principle also applies at the higher echelons of whatever administrative services may be expected to be involved in the implementation of the project. Upper level functionaries, such as those in charge of the Solar Energy Laboratory at Bamako, have been conditioned to expect to live at an international middle class standard for which their salaries do not generally allow. Pressures for them to meet these expectations, which are openly expressed among middle class Malians, may be sufficiently strong to effect work performance. And thus, again, where monetary rewards are perceived as inadequate to meet what are seen as reasonable needs, a diminished level of motivation and job performance will ensue. For a portion of such persons' time and energy will be redirected toward other activities intended to make up the income gap. This problem is not, of course, unique to Mali. It is an attribute of the professional labor market in most developing countries. It is a factor no donor can wholly control. It may be a problem that can never be entirely eliminated in developing countries whose elites take as their model the living standards of technologically advanced western nations. However, it can and should be recognized and realistically planned for. In some instances it should be expected that those in charge of project management at several levels may be somewhat less productive than would their counterparts in countries where their pay could be higher.

So far the motivation of Mali's herding peoples to participate in the project, their desire for easier access to the more abundant water supply solar pumps could offer, is unquestioned. Determination of the economic terms of such access will be the critical variable. Currently underway at

the OMBEVI training center at Dilly is a study of the potential role of newly-formed herder associations. These groups have been set up across ethnic boundaries in order to involve all those whose livelihood is dependent on the management of a single water supply system. The outcome of this research should be carefully monitored during the survey, testing, and evaluation phases of the project.

Minimum Participating Profiles

The minimum requirement for participation in the project and its benefits would be young adult status and reasonably good health. No formal education would be needed for the majority of project participants. The village enumerators working under the aegis of the Unité d'Evaluation should be literate in French and should have received the brief training necessary to read technical materials prepared in the vernacular. They would also receive instruction at the Unité d'Evaluation in survey techniques. Those responsible for the maintenance of all appliances would have to receive formal technical training; they also should be literate in the vernacular. Much of this training could be provided at the local level.

To the maximum extent possible, much instruction can be conducted in the local language. The National Direction for Functional Literacy and Applied Linguistics is, for example, already engaged in the preparation in local languages of materials in the several principal languages indigenous to Mali, notably Bambara and Peul. They have offered their cooperation in the preparation of training and maintenance materials in local languages. Persons such as Kalibou Tera, who is preparing his doctoral thesis in applied linguistics, and Adama Ouane, chief of the Division de Recherche de Linguistique Pedagogique, could serve as useful points of contact.

Given the structure of authority in the rural Malian community, with its strong emphasis upon male dominance, it can be expected that young adult and early middleaged men will be the principal participants in those aspects of appliance maintenance which occur at the village level. Women are likely to take an active role only in those instances where they are allowed to assume direct responsibility for the apparatus. Devices such as solar grinders, improved woodburning stoves, and food dryers, all of which are designed to alleviate traditionally femade tasks, will lend themselves particularly well to control by those who use them.

It will be a major objective of the ethnographic surveys to identify the specific institutional means by which users' control of all new technologies can be maximized. A balance will have to be maintained between due respect for indigenous status hierarchies, in which most prestige accrues to males of noble lineage and to Moslem religious leaders, and the necessary development of strategies that ensure that ethnic minorities, casted groups, persons of slave descent, and women have equal access to project benefits.

As for the processes of adaptation to the new technologies, an extensive and well thought out extension plan must be formulated which allows for experimentation with the new devices, recording of problems of adjustment, both technical and cultural, and for subsequent modification and further testing, before the new devices are widely distributed. It will require at least a full year of pretesting surveys in order to acquire the background technoeconomic and sociopolitical data against which the achievement of project goals can later be measured. Following this, devices will be placed in a selected number of test sites. Some will be put with individual family groups, others will be provided to various kinds of local associations, still others will be installed under the managerial aegis of local government sponsored institutions. The problems of their acceptance, in both technoeconomic and sociopolitical terms will then be monitored over a 2 1/2 year period. During the final evaluation phase of the project the results of this testing will be assessed and further modifications will be suggested which should lead to the development of appliances of proven acceptability to the rural majority.

Every level of local community structure — the kin group, associations, religious organizations, and local branches of such nationally based organizations, and local branches of such nationally based organizations as the Union Nationale des Femmes du Mali and the Association des Jeunes — should be used to disseminate information about the use of the appliances, the opportunities they offer for saving energy and money, for easing arduous tasks, and about their potential as contributors to the development of the rural Malian economy. Circulars in the vernacular, radio broadcasts, and public gatherings should all be used in part of a well-organized campaign to familiarize the target population with the productive potential of such devices, and with the means by which they can be acquired.

However, the widespread distribution of such devices will begin only after the testing and evaluation phases. At a minimum these third and fourth phases of the project will take three years. The need for substantial reorganization of the Solar Energy Lab at Bamako may delay the onset of phases three and four so that the project will last for a minimum of five years. Thereafter, widespread transition to reliance on solar energy devices in rural Mali will be a gradual process measurable in units of ten and twenty years.

Matching Participators and Projects

Once the efficacy of the solar devices is demonstrated there is reason to believe that the rural populace will cooperate in their testing. Those factors which might potentially result in resistance would have been identified during the survey phase and measures to correct them would be introduced during the following test phase that would precede both evaluation and the widespread installation of solar devices at the rural level.

A range of devices has been selected — improved woodburning stoves, solar pumps and solar cereal grinders, solar cookers and solar dryers, solar devices for lighting and for recharging batteries — that assures that the traditional and modern technologies of all segments of the rural Malian population will be beneficially affected. Improved woodburning stoves will meet felt needs throughout a countryside where the scarcity of fuel for cooking is everywhere a problem. All Malians consume large quantities of cereal grains whose processing will be facilitated. A more ample water supply is needed nearly everywhere. Food dryers will eliminate wastage in the preservation of fish and will allow for storing nutritionally important fruits, such as mangoes, which are currently available for only a few short months. Increased lighting is a similarly widespread need. Transistor radios, the batteries for which will be recharged using a solar device, are both a valued possession and an important mechanism for communication.

There is no segment of the rural populace that would not appear to benefit from the proposed new technology. Were they to fail to do so, the reasons would not derive from any culturally determined sources of

resistance relating to rural Malian conservatism. Rather, it would most likely result either from unsatisfactory experience with the technical performance of the new devices or from managerial inadequacies or abuses causing consumer dissatisfaction is built into the survey, testing, and evaluation phases of the project.

It is likely that young adults and the younger middle-aged will be more receptive to the innovations than are their elders. These younger groups are likely to have more experience with industrialized technology. Their relative youth will also contribute to the greater ease with which they adapt to change. However, undue conservatism should not be attributed to more senior groups. Rather, their reticence will more likely be the result of the memory of past ventures in technological innovation that have failed.

Those who will not participate in the project are only those who live beyond its potential bounds and have no opportunity to enjoy its benefits. Presumably they will have a chance to benefit later, after the new technologies have been successfully tested and are ready for wider dissemination. Devices will be tested in all the ecological zones of the country in which sunlight and/or wind conditions are appropriate. As the cultures of neighboring groups among whom the devices will not be tested are fundamentally similar in their institutional structure, there should be no cultural barrier to the successful diffusion of well tested appliances into other areas where natural conditions are suitable.

Obstacles

No obstacles to acceptance of the proposed innovations are likely to come from the traditional cultures of the rural populations of Mali. If the devices are technically sound and if they are made available under terms which allow those who receive them to gain a clear sense of the rights and obligations entailed in their use, there should be no important resistance to their dissemination. The devices must demonstrably meet traditional needs in improved ways: making water and firewood collection easier; facilitating food preparation and storage; providing a means of saving for community buildings at low cost, etc. If they respond to these needs they seem certain to be accepted.

Resistance, if it is forthcoming, will not be to the devices themselves, but to defects in the institutional matrix through which they are introduced. The economic, social, and political aspect of the relationship between the recipient population and those who receive the new technologies are the critical variables. If they are introduced with coercion or are associated with objectionable governmental intervention or, if equitable financial and economical arrangements between users and managers are not clearly understood and mutually acceptable, resistance is certain. Similarly, if the Solar Energy Laboratory personnel, the representatives of other governmental agencies, the enumerators, and the local maintenance staff fail to maintain open lines of communication and to win the confidence of those they serve, then the likelihood of the innovations being accepted will be greatly reduced.

These potential obstacles have not been ignored in the project design. Because their seriousness is recognized, the testing period is designed to allow for identification and rectification of as many infrastructural sources of weakness as possible before the devices are more widely distributed.

Communication Strategies

For the early starts and for the testing phase, it should be the responsibility of the Solar Energy Laboratory to develop a kit of informative materials on the design and function of each solar device, on the steps to be taken when repairs are required, and on the rights and obligations of the users. These materials should be prepared in simple French and should be amply illustrated. They should then be translated into the major languages of the user populations. Those responsible for the maintenance of each device at the local level should receive some brief training in the appropriate presentation of these materials in the vernacular. As indicated earlier the services of the Direction Nationale de l'Alphabétisation Fonctionnelle et la Linguistique Appliquée (DNAFLA) should be used in their preparation and dissemination.

Those responsible for the maintenance of a particular device also should be instructed in the techniques of publicly explaining its workings and the conditions under which it is available for use, how it is repaired, etc., all in the local language. The format for such verbal demonstrations should be provided under the technical direction of the Solar Energy

Laboratory and a tentative schedule of presentations should be worked out with those responsible for each device. These presentations should include provisions for questions, and should be made as part of regularly scheduled meetings of all users that allow for the discussion of whatever problems are arising with regard to the technical, economic, or social aspects of the new technology. Such meetings should occur within a familiar context, at gatherings of the women's union or the village council. The results of these discussions should form the basis of reports sent regularly to the Solar Energy Laboratory in accordance with a format the Laboratory will prepare. Receipt of these reports should be followed regularly by site visits by Laboratory representatives. The results of these visits should, in turn, provide the materials for an important segment of the semi-annual Laboratory reports to be issued during the course of the project. At the conclusion of the project a revised version of these instructional materials should be prepared and made available for distribution among all those involved in promoting wider reliance on renewable energy devices in rural Mali.

Despite the importance of well organized and effectively disseminated information on the uses and potential benefits of solar energy devices, it is important to point out that most rural Malians will be understandably sceptical about the purported benefits offered to them by outsiders bearing the paraphernalia of a strange new technology reliant on an unexpected energy source. Neither written nor verbally stated promises of the project's benefits will elicit commitment of the rural population to the achievement of project goals. That will depend far more on demonstrated technological efficiency and upon users' satisfaction with the terms under which solar energy devices are made available. A plan for the maintenance of open lines of communication, taking the form outlined above, should minimize the growth of unstated dissatisfaction which, if not quickly dealt with, could lead to project failure.

Spread Effects: the Diffusion of Innovation

In order to maximize the potential for the diffusion of the new technologies beyond those sites where they are initially installed, the project will foster the development of devices — improved woodburning stoves, cereal grinders, fish and vegetable dryers — which, after testing,

will be modified in accordance with the technological requirements and cultural needs of specific Malian rural settings. It may, for example, be necessary to alter the design of improved woodburning stoves in response to the different kinds of firewood used for fuel and different kinds of cooking needs in the savannah and sahelian zones. Or, cooperatives which use solar powered dryers for preserving fish in Sendégué may prefer a larger and differently designed apparatus than do onion cultivators on the Dogon plateau. It will be a major purpose of the survey and testing phases of the project to ascertain these varying needs in order to maximize acceptance of the new devices and to assure their diffusion.

With the exception of grinders, these are all relatively small scale devices that require neither extensive capital to acquire nor heavy costs to maintain. In the instance of larger scale devices, such as photovoltaic pumps for irrigation, market gardening, and livestock raising, test sites will be selected on the basis of the proximity of organizations, usually Malian government enterprises, that have the capital resources and the managerial capacity necessary to maintain them. The visibility of the "early start" sites in association with the Mali Livestock II project at Dilly, at a market gardening project located near the important city of Mopti, at the projected new Solar Energy Laboratory in Bamako, and at the Rehabilitation Center for Former Leprosy Patients at Samauko will assure that their successful operation is noted. This will maximize the likelihood of their adaptation by similarly organized entities elsewhere.

Testing will occur at two levels. The result will be a double list: one of appliances suitable for wide distribution to small rural communities and another of devices more amendable to installation, in connection with governmentally sponsored organizations with the infrastructure necessary to assure functioning. All devices are designed to meet the needs of the Malian majority most in need — those whose livelihood is dependent upon subsistence farming on poor land where rainfall is uncertain or upon livestock raising under ecologically even more fragile conditions.

A further major factor favoring the wide dispersal of the solar energized devices to be developed during the course of the project has already been referred to: that is that most have the promise of alleviating the workload of women. The technical efficacy of food dryers and cereal grinders is very nearly proven. What remains to be learned is the most

effective means for introducing such appliances at the village level. It will be a major task at the survey stage of the project to identify those local institutions based on the kingroup, on traditional or modern associations, or on the political system that will serve as a managerial matrix for acceptance of the new implements. The technical benefits of the technologies, in easing the burden of difficult tasks and in increasing productivity, should spread by word of mouth. More critical will be the problem of devising a strategy for demonstrating their economic benefits and for providing the credits needed to facilitate their spread. In the instance of larger devices, such as solar pumps for village irrigation or livestock watering, which may always have to have some measure of external support, technical feasibility is the more important consideration. Institutions organized to effect their efficient management already exist.

Allowance for identification and development of devices that will be potentially suitable for adoption in all environmentally suitable regions of rural Mali is provided for by the selection of survey and test sites in all of the country's major regions in which sunlight is adequate to assure the effective functioning of solar devices, from Koutiala in the northern part of the savannah to the Cercle of Bourem on the edge of the Sahara. Testing for variability in the efficiency of particular devices in particular settings has been carefully provided for, also. Once properly tested for each locale, it is anticipated that all the devices selected could be readily diffused throughout the ecological zones of Mali for which they will have been specifically designed.

Leadership/Authority

The political structure characteristic of rural Mali has been discussed above. In every community the primary locus of decision making authority lies with the elders of each lineage. Collectively they form the membership of the council of village elders led by the village chief. He is usually the eldest responsible male member of the local community's founding lineage. Local representatives of the national government, functionaries attached to the arrondissement or cercle headquarters, have power that is also recognized. The amount of prestige they enjoy is more variable. Local religious leaders, the marabouts, usually have considerable secular as well as supernatural authority. All three sources of political

power need to be recognized to assure the formal approval necessary to group and individual acceptance of the new technologies.

The guidance of local leaders should be solicited. Sensitivity to the Malian protocol for such initial encounters between outsiders and local leaders, and for whatever arrangements may ensue in the source of negotiations on installations, will be ensured both by the guidance of the anthropologist or sociologist working with the project and of appropriate personnel from DNAFLA. Follow-up visits, as confidence gradually grows, will allow for discussion of the innovations proposed and of how best they may be introduced into specific rural communities. Out of these exchanges will come understanding of the probable present and future role of particular local political leaders in fostering adaptation to the changes the survey and testing phases of the project entail.

One caveat is in order. Formal recognition of the power of such political figures and deference to the legitimacy of their authority must be paralleled by critical attention to the possibility that the interests they represent may not be identical with those of all other segments of the rural population. If it is later learned that persons of slave descent, women, or the members of certain castes have needs and concerns to which the traditional male-dominated oligarchy is not responsive, then a strategy for learning of such needs and for assuring that such groups have a share in project benefits must be devised. The special attention necessary to ensure that the needs and interests of women are adequately taken into account in project implementation is provided for in the context of the ethnographic surveys designed to identify the indigenous systems for the differential allocation of economic power and social influence that prevail throughout rural Mali, particularly in the north.

As has been indicated, in many local communities there are those who enjoy considerable authority because of their wealth or religious status. Moslem religious leaders most often fall into this category. One must neither ignore the ability of such leaders to affect public opinion and action nor allow them to use that ability to redirect project activity to meet their own private needs. In the introduction of any of the new technologies, care must be taken not to provide such persons with the privileged access which would further enhance their already privileged socio-economic position.

Again, the ethnographic surveys planned for Phase II of the project will allow for the accurate identification of such persons and, in the testing and evaluation phases, for the development of an approach to the introduction of solar energy devices in a manner that assures that the requirement of equity in the distribution of project benefits is effectively met.

In addition to these traditional sources of leadership, it will be important to identify what may be the more dynamic elements of the local population. These may often be leaders in the young peoples' associations, either those who head the indigenous voluntary associations based on sex and age (the ton in Bambara and Manding) or members of new forms of associations based on political interest, such as the Association des Jeunes or local chapters of the Union Nationale des Femmes du Mali. These groups are of particular interest because they frequently represent efforts to transform traditional Malian social groupings to meet new needs. In addition, they often provide an alternative source of mobility to those who have few hopes of achieving higher status within the context of indigenous institutions where their youth, their sex, or their ethnic identity is an impediment to advancement.

In the instance of the Union Nationale des Femmes du Mali, some local chapters in rural areas have already had experience in fulfilling the corporate functions necessary to the successful introduction of solar energy devices at the local level. At Dioila, for example, the Women's Union has acquired a diesel-driven cereal grinder, has assumed responsibility for its management, for arranging for its repair, and for making investments with the income it produces.

A value of these new sources of community level leadership is that their membership often cuts across ethnic and social class lines, providing a basis for community-wide economic, social, and political action that transcends traditional boundaries based on ethnicity, class, and caste that otherwise exclude certain categories of the rural population. Reliance upon these new organizations can thus increase the chances of equity in the allocation of project benefits.

Patterns of Mobility

The patterns of mobility typical of the rural majority in Mali vary in accordance with age and sex. Young men from fifteen to thirty-five are

the most mobile. For some of the young men who go off early in the harvest season to seek work in the cities or on the plantations of the Ivory Coast, this work is only seasonal. They return in time for the following year's planting season. Others stay away longer, returning permanently only when they are ready to marry or when they have become eligible to inherit property or positions of some leadership at home.

The impact of the returned migrant's experience upon indigenous patterns of culture at the village level is frequently less marked than might be expected. That this should be so is further explained by the fact that young people who return home have little power or prestige which they can exert to affect change. Those who return when they are older and have more authority are usually eligible for positions of high status within the indigenous societal hierarchy and have less interest in altering a social situation which now works to their benefit. As a result, most changes in cultural behavior resulting from the mobility of the younger sector of the labor force have to do with minor alterations in consumption habits: an increased desire for manufactured goods, clothing, bicycles, coffee and sugar, dark glasses and transistor radios. It is these discrete items encountered abroad, rather than whole patterns of behavior, that are most readily diffused to home communities on the migrants' return.

Women and young girls are much less mobile. When they do leave their home communities, it is usually to join their husbands elsewhere rather than to seek employment on their own. Men leave home infrequently and women scarcely at all. For this segment of the rural populace, long distance travel is too arduous. They travel short distances to visit kinsmen, to seek medical attention, or to accomplish specific commercial objectives.

To maximize the possibility for diffusion of project devices, it would be desirable to place a number of them in regional centers: in market towns, at the seats of local government, and near government-sponsored local institutions such as schools and dispensaries. The selection of sites for the testing phase of the project has been planned taking these patterns of mobility into account.

It remains true that despite extensive mobility among rural Malian youth, the social distance between migrants and those they move among minimizes the chances for some types of learning. However, the behavior

patterns of the educated class and of city dwellers carry considerable prestige. The way of life of civil servants living in rural areas is also regarded with admiration. So long as the new devices to be disseminated by the project are not limited to this already privileged segment of the population, the acquisition by them of improved woodburning stoves, food dryers, and hot water heaters that operate efficiently seems to enhance their spread effect.

Previous Project Design and Execution

A few solar energy devices have already been installed in Mali. But in nearly every instance these are complex and expensive apparatuses put in place and maintained by outside agencies. Their acquisition, management, and maintenance all take place outside the context of indigenous Malian institutions. Familiarity with these devices and with the energy sources that power them is limited to interested specialists. The sole device that has been disseminated on a somewhat larger scale is the solar water heater. It has been installed on the roofs of the homes of some Malian government officials in Bamako, and in one of the capital's hospitals. There is a potential demand for such heaters, as the availability of hot water for bathing is much desired. However, these heaters have not yet been perfected, and it appears that their current cost and rate of repair may make them uneconomical even to the Malian middle class with the material means to obtain them. So far their dispersal is very limited. This may be an advantage, in that once properly tested and perfected, solar energy devices can be introduced without fear that efforts at their dissemination will be burdened by a legacy of past failure or of coercion.

Positive demonstration of the manifest material benefits of project devices will be the way to win their wide acceptance. Pressure for participation in the project at any point is likely to be strongly counterproductive.

Maximum Information and Resource Distances

What must ultimately spread are solar energy devices which, for the foreseeable future, will have to be manufactured either abroad or in Bamako. Only the improved woodburning stove may be sufficiently simple that it can be fabricated at the rural level. What must also spread are

the techniques by which these devices are obtained, used, and maintained. To maximize the chances for such spread, the project will foster the development of devices and of procedures for use that are as simple as is practically feasible. The institutional development, survey and testing phases of the project will take five years. Thereafter it is probable that widespread adoption of well tested devices will take another ten to fifteen years.

Assuming that the test phase results in the development of models that are technically efficient and culturally acceptable for use at the village level, the only constraint on their spread will be the availability of the capital necessary for their acquisition and the development of a service adequate to their maintenance. Alternative means of local financing will be tentatively identified during the survey phase of the project, tested during phase three, and evaluated in phase four. In the instance of such devices as cereal grinders acquired by local groups, revenues should ultimately be adequate to purchase additional models.

An outcome of the evaluation planned for phase four of the project will be a more accurate estimate of the amount of time required and the conditions necessary for the widespread dissemination of the new technologies. A major factor in determining this will be the rate at which the price for solar devices continues to fall.

Social Consequences and Benefit Analysis

Women are probably the single group within Malian rural society who will benefit most from the project. For it is their most arduous tasks that will be eased: as improved woodburning stoves and solar cookers release from them the time consuming search for firewood; as solar energized grinders relieve them of the hours of tiring work most now spend pounding grain; and as pumps powered with solar energy facilitate the task of drawing water. All these jobs - gathering firewood, grinding grain, and carrying water are typically added to women's work in the fields. Childcare and household maintenance are also their responsibilities. Women rise before dawn to heat water for their husbands and to prepare the family breakfast, and they are frequently the last to retire at night. Any reduction in this work load seems certain to be welcome, and released time

could be reallocated to tasks clearly of benefit to the entire community. Additional time spent growing garden produce would provide women with a source of increased money income and would allow for an improved and more varied diet. There would be more time for adequate childcare and for household maintenance.

It will be a major objective of the project to analyze women's work during the survey and testing phases and to develop both alternative energy devices and procedures for the dissemination of such devices that will maximize their potential benefits to women.

Others most likely to benefit from the project are those who live in the marginal areas of Mali where one or another of the basic resources required for human survival is in chronically short supply. The most critical of these resources is water. Providing readier access to water to the herding peoples who live in the northly zones of Mali will enable them to continue a way of life that is in persistently delicate balance with a harsh natural environment. The likelihood of their movement south will be decreased and competition for available farmland will be lessened thereby. For settled farmers an augmented water supply will enable them to increase their reliance on gardening activities as an important subsidiary source of income. It will also allow them to care for their animals more productively. The result could be the development of a more diversified, and thus more secure, material base for rural Malian society.

It is difficult to identify "those who might be adversely affected by the project." Presumably they would be those who presently supply the rural populace with energy, fuel, batteries, etc., at high cost and those few who have a monopoly on access to such useful devices as cereal grinders. Their number would be small. Increased competition would be good for them.

In brief, the benefits of the project would appear to extend potentially to the entire mass of the impoverished rural poor. To the extent that some of the more complex solar devices would require installation in centers where ownership and management could not realistically be expected to be vested in local hands, the improved operation of such enterprises as hospitals and dispensaries, agricultural research stations, and community buildings, would clearly benefit the entire population. To the extent that reliance on solar energy would decrease the operating costs of such organizations, the amount of services they could provide

would be extended. These services are directed either to groups in critical need or to the public at large. The Malian majority will clearly benefit.

Because of their scale and maintenance requirements, some devices will be suitable only for installation in or near urban centers, but most will be placed in rural settings. An appropriate balance thus will be assured between the needs of the cities and larger towns and those of the countryside.

With regard to "assessment of the benefits and burdens" of the project it will be imperative to ascertain that controls are instituted to ensure that once farmers and herdsmen have switched to reliance on solar energized devices, the price for providing these devices and for their servicing is not allowed to rise so as to offset the benefits they provide. Careful attention must be given to this consideration by those who take responsibility for setting prices. Any later switch in the terms under which such services were provided would gravely jeopardize the realization of project objectives.

Similarly, it will be essential that those whose labor-time is reduced by the introduction of new technologies themselves have control over the reallocation of such time. Women released from the ardours of collecting firewood only to find themselves assigned an additional workload in their husbands' fields should not be expected to endorse such innovations with enthusiasm.

Access to Resources and Opportunities

It will be a major objective of the final phase of the project to identify those local level institutions which are best set up to allow for the acquisition and management of solar energy devices. In the instance of larger appliances such as pumps and grinders, it will probably be some local groups that take on this responsibility. It is anticipated that such groups will be broadly based in their membership, representing a substantial cross section of the local population. Two examples of such groups have already been cited. One is the traditional age-based association which places together all those who have been initiated at the same time. Such groups have male and female leaders and a long tradition of pooling their work efforts in the pursuit of a common goal, the construction

of a community center, the organization of a dance, or the purchase of medicines. Sometimes they operate as rotating credit organizations. Voluntary associations based on age are democratic in their organization and might well serve as an appropriate local organization to take over the management of solar devices.

Other examples are politically-based chapters of the Union of Malian Women. Small villages of homogeneous ethnic composition could also assume such corporate functions. From what is now known, reliance on any such organizations as these would appear to maximize the chances of the local majoritiy's participation in project benefits. It is anticipated that the survey and testing phases of the project will identify other organizational models that will provide for local level control and the assurance of equity.

The precise mechanisms for the extension of credits necessary to acquire the larger of the solar devices will be identified in the survey planned for phase two of the project. In some instances such assistance with financing may not be necessary, as many local organizations are reported to have already developed means of accumulating significant amounts of investment capital; women's unions and age associations, for example.

Those smaller devices such as improved woodburning stoves are likely to be obtained by individual households. Fuel and labor savings will be their prime attraction. The same may be the case for fish and vegetable dryers. However, they are likely to be more attractive to the collective membership of extended families. Dryers used for commercial fish drying should be most suitable to the women's associations traditionally organized to undertake this task.

Care must be taken to avoid placing such income producing devices in the hands of local merchants and others whose position in the socio-economic structure is already often privileged to the point of being exploitative.

Employment

In part this issue has already been covered. To the extent that new project technologies save labor, it is to be expected that this labor will be reallocated both to diversify the economic base and, in the instance of women, to free time for improved child care and household

maintenance. There is no portion of the local rural population that is likely to be thrown out of work by the introduction of the devices proposed.

A number of people will acquire skills during the early phases of the project which should enhance their chances of productive employment later. The enumerators who will be responsible for the village level surveys will, thereafter, be a valuable research resource, for their field survey experience will leave Mali with a cadre of young women and men skilled in the techniques of collecting the sort of baseline technoeconomic and sociopolitical data which should be the first step in the introduction of any new technology in the rural areas. At a higher level, the increased training and experience acquired by the professional staff of the Evaluation unit of the Rural Economy Institute will also augment a needed in-country skill. Through participation in the survey, testing, and evaluation phases of the project the staff of the Solar Energy Laboratory, OMBEVI, Génie Rural, the Direction Nationale d'Hydraulique, DNAFLA and others will have the opportunity to become sensitized to the critical economic and sociocultural dimensions of successfully introducing any new technology among Mali's rural majority.

Rural Displacement, Migration, and Urbanization

No displacement of rural population is anticipated as a result of the project. On the contrary, by facilitating some of the more difficult tasks associated with traditional village life and increasing income possibilities in the rural sector, a result of the project should be to keep on the land some of those who presently leave to seek what they perceive as the easier and more remunerative work available abroad. For those who live in the smaller towns, the amenities the project can provide — the lighting of public buildings, dispensaries with improved facilities, cleaner drinking water — can have the effect of decreasing the exodus of the educated young to the already overcrowded cities.

Changes in Power and Participation

The most important power shift that can result from the project bears upon the subordinate status of women. By easing their present onerous labor load and allowing for the rellocation of a portion of their work time

to tasks which will benefit them directly, such as gardening, they will have the opportunity to increase their economic independence, an essential condition for increasing their social power. In a society in which most traditional institutions operate to sustain the subordinate status of women, realization of this same objective will be facilitated by strengthening women's organizations through allowing them to acquire and manage some of the new devices. This will enable them both to accumulate more capital and to develop the managerial skills that are equally essential to the achievement of greater socioeconomic autonomy. The effect on the young people's associations will be the same.

In brief, groups that are presently subordinate to the control of an older, more conservative male-dominated generation will be provided the chance to acquire more income on their own and thus to achieve that greater measure of independence that allows for still further experimentation with new and alternative technological means of coping with Mali's pressing economic problems.

NOTE

As for the "institutional factors and relationships among GRM agencies which will affect the success of the project" (see page 3 of the Scope of Work, Mali Renewable Energy Project Paper), the organizational weaknesses of the Solar Energy Laboratory at Bamako are discussed in Appendix E. The Laboratory apparently suffers from some of the same disabilities that afflict many such institutions in developing nations. Money for staff salaries is available, but not on reliable basis. The GRM provides a tiny operating budget. As a result the Laboratory Director's responsibilities as a fund-raiser appear to have left him with neither the time nor the poised intellectual perspective needed to develop a long term research and development program for the organization he heads. This fundamental deficit then weakens his position when he seeks support from a source such as USAID that is prepared to carefully scrutinize the status of his current program before providing additional support. This "institutional" problem probably derives from the precarious financial status typical of most facilities in developing countries. The varying priorities of each donor make an erratic research record hard to avoid.

The problem must, nonetheless, be corrected. A means for setting the Solar Laboratory on a more productive and stable course is outlined in the description of Phase I of the project.

The "implications of local cultural and social factors for selection of specific technologies" (see page 3 of the Scope of Work) is extensively dealt with during the survey, testing, and evaluation phases of the project. For an outline of the content of the ethnographic survey planned for phase two of the project, see Appendix H.

AMPLIFIED PROJECT DESCRIPTION

The following paragraphs provide more detail on the activities and organization of each phase of the project.

Phase I

While the program to be established by the Solar Energy Laboratory should not be predetermined, discussions between Lab staff and the PP team have focused on a program which would give the following elements a high priority.

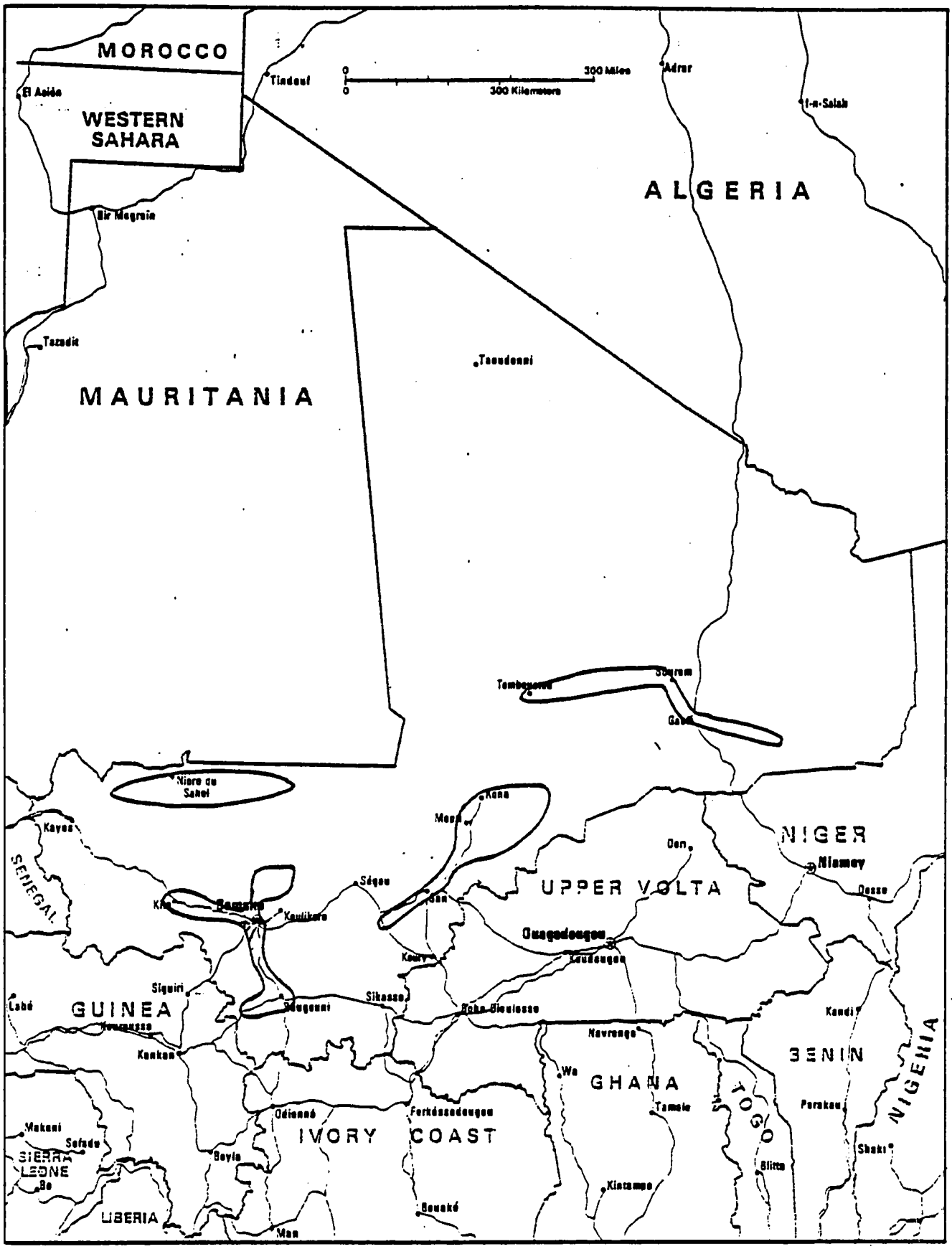
1. Install and operate insolation, temperature and wind measuring equipment.
2. Conduct quantitative performance tests on the Lab's present hot water heater.
3. Improve construction of the hot water heater.
4. Conduct quantitative performance tests on the Lab's prototype crop/fish dryer.
5. Improve construction of the crop/fish dryer.
6. Begin development of an efficient woodburning stove using readily available materials.
7. Develop a photovoltaic battery charger, emphasizing reliability and ease of operation.

Phase II

This phase undertakes the scientific, social and economic survey of 25 potential test sites. The general location of each site is listed below. The list was drawn up by the Malian project committee and later modified slightly by its chairman in consultation with the PP team. Specific villages within the administrative districts (Cercles) will be chosen during Phase I by the committee.

Group I - Nioro	Group II - Bamako
Cercle de Nioro - 2	Cercle de Banamba - 1
Cercle de Yelimané - 2	Cercle de Kolokani - 1
OMBEVI pastoral zone - 1	Cercle de Kita - 2
OMBEVI villages - 2	Cercle de Bougouni - 1
Total = 7	Cercle de Yanfolila - 1
	Total = 6

Mali



502728 9-77 (542184)
Lambert Conformal Projection
Standard parallels 8° and 32°
Scale 1:11,000,000
Boundary representation is not necessarily authoritative

LOCATION OF POTENTIAL SITES

Railroad
Road
Airport

Group III - San

M'Pessoba - 1

Yankasso - 1

Dogon area - 2 (irrigation & onion drying)

Mopti Livestock Operation - 1 (ODEM)

Kona & Sendégué - 2 (fish drying)

Total = 7

Group IV - Gao

Ménaka - 1

Rharous II - 1

Diébok - 1 (45 km from Gao)

Cercle de Bourem - 1

Cercle de Tombouctou - 1

Total =5

At each potential site the survey would be tailored to specific devices that appear suited to the site. Measurements of sunshine duration, temperatures and wind velocity would be made at the appropriate sites. The other elements of the survey to be pursued in a particular village would focus on the aspects of village life that would be altered by the introduction of alternate energy technology. Thus, in a village where photovoltaic cereal grinders are being considered, the survey will study local production and availability of cereals (sorghum, millet, maize), local customs with regard to grinding for flour, the amount of female labor devoted to grinding operations, the existence and importance of commercial grinding with conventional power, and so on. As a result of this emphasis, other elements in the comprehensive list of survey topics found in Appendix H would receive less attention. Certain basic data on the social structure and economic life of the village would be gathered at all 25 sites.

The surveys would be conducted under the overall direction of the Institute of Rural Economy's Evaluation Unit which has been carrying out in-depth village-level surveys since June 1976. The person in charge of the survey would be a Malian staff member of the Evaluation Unit who would have attended the Summer Institute in Survey Research Techniques at the Survey Research Center, University of Michigan, or some similar training session. Assisting the director would be an engineer from the Solar Energy Laboratory. The individual would serve as the permanent liaison between the lab and the survey. Along with personnel from the Meteorological Service, he would train the survey enumerators in the proper collection of the scientific data that will be required. He would visit potential sites periodically to verify these measurements as well as to stay abreast of progress on the survey.

The engineer who serves in this liaison function would direct the tests conducted on the chosen sites in Phase III.

In order to give the survey cohesion and purpose an American social anthropologist would be hired under contract to (a) prepare a synthesis of known facts relevant to the survey, (b) assist in designing the survey, (c) participate in the training program for the enumerators, and (d) participate from time to time in the survey and testing phases of the project. This would involve several trips to Mali over the life of the project. A more detailed description of the job is found in Appendix M.

The potential sites listed above have been delineated in four zones to facilitate supervision of the enumerators by four middle-level teams, each one of which would cover five to seven sites from a different home base. Group I would be supervised from Nioro, northwest of Bamako; Group II from Bamako; Group III from San; and Group IV from Gao. The supervisory teams would each have a Peace Corps volunteer with a bachelor's degree in the social sciences, some command of statistics, and knowledge of French. If Peace Corps volunteers could not be obtained, U.S. graduate students at the dissertation level could be used. The second team member would be a Malian controleur recruited at the baccalaureat examination level. Each team would be equipped with a four-wheel drive vehicle to enable it to move from site to site on a regular schedule.

If it can be fitted into the schedule, the Peace Corps or U.S. graduate student supervisors would also attend the eight-week Summer Institute at Michigan or its equivalent, in July-August 1980. Their U.S. training should be complemented by participation in a pre-fieldwork seminar conducted by the consulting social anthropologist on the ethnological concepts underlying the selection of ethnographic survey categories. During the course of the survey the U.S. consultants would make periodic field visits, and there would be a mid-survey conference bringing together the survey director, the consultants, and the supervisory teams to assess progress toward survey objectives and to make modifications as necessary.

The site surveys will actually be conducted by teams of two enumerators resident in each village, or a total of 50. Because there will undoubtedly be dropouts, illnesses and ill-suited candidates, a greater number — perhaps 65 — will have to be recruited, selected and trained for the role. The Evaluation Unit has done this in the past, though on a much smaller scale, and

has had its best results with local recruitment at the Cercle (district) level. The Units; village-level enumerators have been young Malians with nine years of formal education (D.E.F. level) who have not gone on to secondary school. With adequate training and supervision, enumerators recruited at this level should be able to perform effectively. The training program would take place in or near Bamako and would last about three weeks.

The supervisory teams would be expected to establish a schedule which would take them to each site about once every three weeks for a day or two of observation and work with their enumerators. Such a schedule would not require the teams to travel much more than 50 percent of the time. The Bamako team, for example, could spend four days of one week at the Bougouni/Yanfolila sites, three days of the next week at the Kita sites, and four days of a third week at Banamba/Kolokani. In addition to regular visits, the teams would also meet with their respective enumerators in a group or groups both before and after the mid-survey conference.

A representative of the Functional Literacy service (DNAFLA), Guy Belloncle, has suggested that the enumerators should not arrive at their village sites before the village is prepared for them, nor should they arrive empty handed. It is essential, according to Belloncle, that the village understand that potential benefits from the new technologies will be available to any villagers who are willing to participate in the project rather than just to favored individuals or families. Therefore, before specific villages are chosen as survey sites, the services of local DNAFLA personnel should be used to organize village meetings to ensure that there is village understanding of and commitment to the project's objectives and its activities.

Belloncle also believes that the enumerators should come to their village with some form of solar device which would demonstrate that the technology works and that there are tangible benefits to be obtained from it. The danger of such an approach, in the view of the PP team, is that a given device may have sufficient impact to distort the pre-test baseline data. It may also take an inordinate amount of the enumerators' time to operate and maintain, or it may not be adequately perfected and break down often. The PP team has therefore concluded that it would be best to leave the matter open for the time being. If a small device such as a water heater, dryer or solar cooker could be used occasionally by enumerators without significant impact on village life and without taking much of their time, it would be

worthwhile to provide such a device for about half of the village sites. The reactions of the villagers could be duly noted during the survey.

One of the crucial responsibilities of the four middle-level supervisory teams would be to work with each village over the period of a year toward the objective of choosing villagers who, either as individuals or as representatives of village organizations, would become "village cadre" in Phase III. The methods used to arrive at this selection may vary from site to site. Villages that show themselves to be unwilling or uninterested in making such a commitment would be unlikely to be chosen as a site for a device in the third phase. The consulting social anthropolgist, aided by personnel from DNAFLA and Animation Rurale, will work with the supervisory teams on a methodology for obtaining village selection of cadre.

In the meantime, as Phase II progresses, the Solar Energy Lab would be expected to be near completion of the various devices that are to be tested in the next phase, and thus to have a sufficient number of prototypes in readiness for installation.

Between the tenth and twelfth months of Phase II, final selection of villages for the testing phase will be made. As a result of meetings in Bamako on May 26 and 29, 1978, it has been agreed that the project committee will make the final choice.

At the selected sites the villagers would then be asked to choose cadre to be trained in the operation and basic maintenance of the appropriate device. The number chosen would vary from village to village, depending on the device or devices to be installed, the number of local groups involved, the size of the village, the preference of the villagers, and so on. More than eight village cadre for one site would be excessive. It should be noted that the cadre would not receive any renumeration except that which the villagers themselves may decide to give them.

Phase III

At the beginning of the phase, the village cadre from the selected sites would be brought to Bamako for training at the new Solar Energy Laboratory. Prototype devices will be available on the testing ground of the Lab for use as training aids: a photovoltaic pump, photovoltaic arrays for charging batteries, lighting, cereal grinding and other uses, a solar cooker, an improved woodburning stove and others. The training program would be under

the direction of the Lab engineer appointed to be in charge of the test phase. The consulting energy scientist, the social anthropologist/consultant, the Evaluation Unit staff, and the supervisory teams would also be available to participate in the training program. There would be one exception to bringing village cadre to Bamako for training. Given the lack of sufficient wind anywhere but in the Sahelian and desert regions of Mali, cadre for the windmill sites would be trained at one of the sites as soon as the equipment had been installed.

Installation of devices will be performed under the direction of the Solar Energy Lab, and appropriate measuring instruments will be put in place at the same time. It will be important that the villagers participate as fully as possible in the installation of the device. They should be consulted as to its location in the village and they should be asked to construct, or contribute their labor to build the ancillary structures which must accompany the device.

In addition the villagers at each site would then be asked to make a contribution toward the cost of the device in accordance with a formula that will have been worked out during Phase II. The amount and form of payment will probably vary greatly from village to village, depending on the device installed, the kind of services obtained from it, the wealth of the village, and its own preferences. In some cases there may be three equal annual installments to be collected by the village cadre. In others, such as those where solar cereal grinders are to be installed, payments may be required for each kilo of cereal that is ground.

The principle to be established is that the villagers have a stake and an interest in the proper operation, maintenance, and durability of their device. It is not to be considered a gift from a benevolent government and foreigners which therefore remains the responsibility of these outsiders. In some cases, at prices that are expected to prevail in 1981, a village payment would still represent only a fraction of the cost of the installed device. Yet the subsidy that would be inherent in installing these test devices would be an investment in developing them to the point where they are capable of much wider use. As this occurs, scale economies will result, and over time the amounts charged to villagers for devices that are more tested, durable, and efficient would be expected to approach the actual cost of the installed device.

The enumerators chosen for the test phase would be the best of those employed in the survey phase who wish to remain in the program. There would be only one per test site, however, since the data-gathering burden would be lighter and the village cadre would be trained to monitor the performance of the test devices.

This phase of the program would also retain the intermediate supervisory structure: four Peace Corps volunteers and/or graduate students, each assisted by a Malian controleur. The base of operations for each group of sites would remain the same, and the same vehicles would be used. The number of sites per group would have been reduced, however, from between five and seven to between four and six.

In the early part of the third phase it is expected that the supervisors would be able to devote part of their time to working with the outside consultants on preparing an interim report on the survey. If well done, the survey and its report should elicit wide interest. Funds should therefore be available for translating and reproducing the report.

Data and information-gathering in the third phase will emphasize two aspects of the test. Close observations will be made of the different devices so that an accurate record can be kept of their performance. It would be one of the tasks of the village cadre to note when breakdowns occur, what their nature may be, what is required to restore the device to working order and how long it remains down. The village cadre would also be available to assist enumerators in keeping accurate records of the social and economic indicators established by the survey. Enumerators will focus their efforts on the sociocultural processes of adaptation and on the economic changes that the introduction of a new technology may produce. Animals from neighboring villages may be brought to the site for watering; vegetable gardens may be created for the first time; maize may be grown more extensively; firewood consumption may decrease; or a number of less easily observable social patterns may change.

Phase IV

The test phase will have been planned for a two and one-half year period on the grounds that it will take villagers several months to become accustomed to the new devices. It may well be that the most interesting results will not become apparent until well into the second year. Two and

one-half years of testing should suffice, however, for the purposes of evaluating the entire program's efforts and for determining whether answers have been obtained for the five questions posed at the outset. In particular, more than two years of operation, including two full crop cycles, should provide enough data to evaluate the economic viability of various devices, both at the prices at which they were ordered and at the new prices then prevailing. Changes in incomes and well-being should have been observed. The effects of the devices on different segments of the village population should be reasonably clear. The ability or inability of the village cadre, working within village organizations, to operate and perform routine maintenance on the devices should have become apparent. The durability of the devices would still be in question, only less than three years having passed, but a number of flaws in design and in adaptation to local conditions can be expected to have appeared.

The evaluation would take place under the joint direction of the I.E.R. and the Solar Energy Lab's project director. It would be organized by means of a conference convened by the project committee in the latter part of Phase III. Criteria for the evaluation of test results should be explicitly identified. Participants would include the outside consultants, supervisory personnel, local DNAFLA staff and such others as may be useful in light of the situation at the time. A six-month effort to compare the village sites before and after the tests, with full exploration of the performance of the devices, the villagers' adaption to them, and the socioeconomic changes induced, would be required. A final report whould be translated, printed and distributed.

THE SOLAR ENERGY LABORATORY

1. Assessment

The Solar Energy Laboratory was started in 1964. Mr. Cheickné Traoré became director in 1969. The staff grew from three in 1964 to 33 in 1978. It now consists of the director, 6 senior engineers, 3 junior engineers, 8 machine shop people, 7 administrative personnel and 10 workers of various types (gardiens, drivers, etc.). The sum of monthly salaries is $3,790.

The Lab produces solar water heaters, of which about 150 have been installed, although this number may not be precise. About 60 unsold heaters are in the test yard. Current projects are (1) solar air conditioning, (2) drying, (3) distillation, (4) better water heaters, and (5) industrial heating.

There is a paucity of experimental data and/or reports and there are no publications. The measured data that the PP team found was:

- solar still — several sheets of data showing liters of distilled water produced per day with no temperature, isolation, wind or other measurements.
- solar water heater — a few dozen pages of reservoir temperatures as a function of time of day with no insolation, wind, or flow data; 1970-1971 time period.
- SOFRETES pump, Dioila — about 50 days of operating records, start and shutdown time, pressures, water pumped, etc.

None of this data was analyzed and used for comparison to calculated performance. No reports were found that used the data. This is all of the data that was found for the period 1969 to 1978.

The laboratory does not appear to have measured insolation, wind, temperature or humidity. There are no instruments on the premises. Nor are there thermometers, flow meters, scales, or voltmeters.

The PP team inspected the library twice; there are few recent books and only two on solar energy — both rather elementary. A subscription to The Journal of Solar Energy Sciences and Engineering lapsed in 1965. There are no other solar energy journals in the library. There are some journals on nuclear energy and applications.

Three solar water heater installations were inspected. At the

Gabriel Touré hospital in Bamako the water heater serves the delivery room and a shower room that is under construction. The water from the tap in the delivery room was less than 100° F. At the house of a Mr. Keita, the heater is working, producing water that felt to be about 105° F. at midday. The proprietress does not turn the cold water valve off at 4:00 p.m. as instructed. The bottom of the hot water tank leaks onto the roof. At the Hamdallaye maternity clinic in Bamako the hot water faucet leaks, but the water is about 115° F. The tanks must be filled by turning on the cold water valve since the floaters do not work. The tanks were full of leaves and debris.

The PP team was told that there were "fiches" (record sheets) on all water heaters installed by the Lab. These were produced after several requests, but none were filled out. A number of Malians, including the Minister of Industrial Development, under whose jurisdiction the Lab falls, claimed that there is demand for solar water heaters, yet 60 are sitting in the yard. This is an inventory worth $30,000, though it appears that the Lab is not allowed to use the proceeds from its sales.

The PP team requested a copy of the research and development plan of the Laboratory, a list of personnel, indicating their qualifications and pay, the operating budget and a list of donors, showing what they donated and the location of the donated equipment. Almost three weeks later a list of personnel, an R&D plan dated August 1977 and files on donations by CIMADE and UNIDO were received.

CIMADE, a French ecumenical group, donated MF 24,000 worth of equipment about two years ago. Three large machine tools, shears, bender, etc. were acquired and they are currently stored in wooden crates in the yard. The bottom of one crate has been eaten by termites. The state of the machines was not determined.

Conclusions

The director, Mr. Traoré, does not appear to understand the need for basic measurement of the functioning of a solar energy device, nor to consider it necessary. He has failed to supply a number of elementary R&D tools to his engineers. He has provided no current periodicals on solar energy. He has, to say the least, an unusual conception

of the basic functions and functioning of a development laboratory.

Because of long inactivity and almost total lack of experience in laboratory practice (except for visits to foreign countries) it will be quite difficult for the Solar Energy Laboratory to develop the competence needed and to put into operation a functioning laboratory that will satisfy the demands of this program.

2. Suggested Tasks for the Solar Energy Laboratory

Phase I

A. Order equipment, material, books and periodicals.

B. Receive, install and put into operation the collector test stand including pyranometers, temperature and wind recorders.

C. Test present low-temperature collector in standard fashion.

D. Improve construction of hot water heater and adapt to village use. Perform quantitative tests such as amount and temperature of hot water produced.

E. Improve construction of dryer and perform quantitative tests of its performance such as drying rates for fish, fruits and vegetables, temperatures, humidities and volume of air flow at appropriate locations.

F. Begin development of efficient woodburning stove using inexpensive, readily available, materials which are adaptable to village use. Perform quantitative tests such as measuring amount of wood needed to cook a standard meal.

G. Develop photovoltaic battery charger paying attention to reliability and ease of operation. Quantitatively evaluate its performance such as by measuring charging voltage and current.

H. Supervise installation of "early start" solar pumps at 4 sites. Monitor their performance.

I. Train two engineers in the United States.

J. Construct about 12 prototypes for installation in villages during Phase II. These might include dryers, hot water heaters and battery chargers.

Phases II and III

A. Install Phase II prototypes, if desired.

B. Order shop and laboratory equipment and materials.

C. Construct buildings at new laboratory site.

D. Transfer test and construction operations to new site.

E. Assist IER in Phase II village data gathering program.

F. Develop and quantitatively test a high temperature (100° C) flat-plate collector.

G. Develop, construct and quantitatively test items to be placed in villages in Phase III. These will probably include:

1) hot water heaters for community use and dispensary use
2) large fish dryers
3) large crop dryers (e.g. onions)
4) several types of wood stoves
5) solar battery chargers
6) solar cookers
7) solar photovoltaic grinders
8) others as determined by the Phase II village investigation.

H. Install devices at village sites.

I. Continue development and testing of items in (G) above.

J. Install the 1 kilowatt photovoltaic electric generator on the Lab grounds and study its applicability as a village general-use power source for operating pumps, grinders, refrigerators, lights, etc. Investigate energy storage with batteries with ice. Consider conversion of direct to alternating current. Optimize use of the solar cells.

K. Direct Phase III.

L. Assist with the Phase IV evaluation.

3. Terms of Reference For Phase II Evaluation of the Solar Energy Laboratory

Objective

To determine whether the Solar Energy Laboratory is an effectively functioning organization capable of performing its role in the overall program.

Procedure

Examine the physical equipment to see if it is functioning properly and whether it is receiving proper care and maintenance. Determine whether

the personnel understand its operation and are effectively using it. Determine whether the results of tests, insolation and weather data are being properly recorded, reduced, analyzed and compared to theoretical models as necessary.

Examine the devices to be used in the program to determine whether their state of development is adequate to satisfy the requirements of the village testing program. Observe Lab personnel during the operation of the devices and the taking of data, whenever possible. Examine measured performance data on each type of device to determine whether there is enough data of good quality taken under a variety of insolation, weather and other operating variables.

Examine lab personnel to determine their ability to carry on the work without a visiting engineer/scientist in residence. Note their work habits, motivation, ability to work as a group and appreciation of goals to be attained. Determine whether they are technically/scientifically competent in relation to the work to be done. Determine whether the Lab Director is intimately involved in the technical program, whether he is clearly outlining goals and paths to reach them, and whether he is effectively communicating them to the laboratory personnel. Determine whether the Director is properly and effectively using the funds and means at his disposal. Determine whether he is effectively utilizing the personnel of the Laboratory.

Result

Prepare a report of the evaluation covering all significant aspects. Decide whether the Laboratory is capable of satisfying the demands of the overall program. If the answer is no, it must be stated. If it is questionable, the marginal areas should be discussed and remedial action recommended.

State which devices are ready for placement in villages. If a device is not ready, state what should be done to get it ready. If it appears that a device cannot be readied in time for installation at the beginning of Phase III, so state.

4. Solar Energy Laboratory Budget, 1972-1978. (MF 000)

Year	Operating Budget	Capital Budget	Salaries	Foreign Grants
1972	1,012	-	5,620	-
1973	838	-	7,680	-
1974	1,620	10,000	(a)	-
1975	3,050	-	8,934	-
1976	3,306	13,000	15,112	85,980[b]
1977	4,820	6,750	15,662	-
1978	5,250	13,500	20,209	40,000[c]

[a]Figure not obtained.

[b]Grant from CIMADE, 176 rue de Grenelle, Paris. The grant was allocated as follows:

44,022	Dioila dispensary project
8,125	engineer's offices and furniture
12,775	workshop equipment
16,150	hot water heaters (100)
4,500	dryers and stills
408	other
85,980	

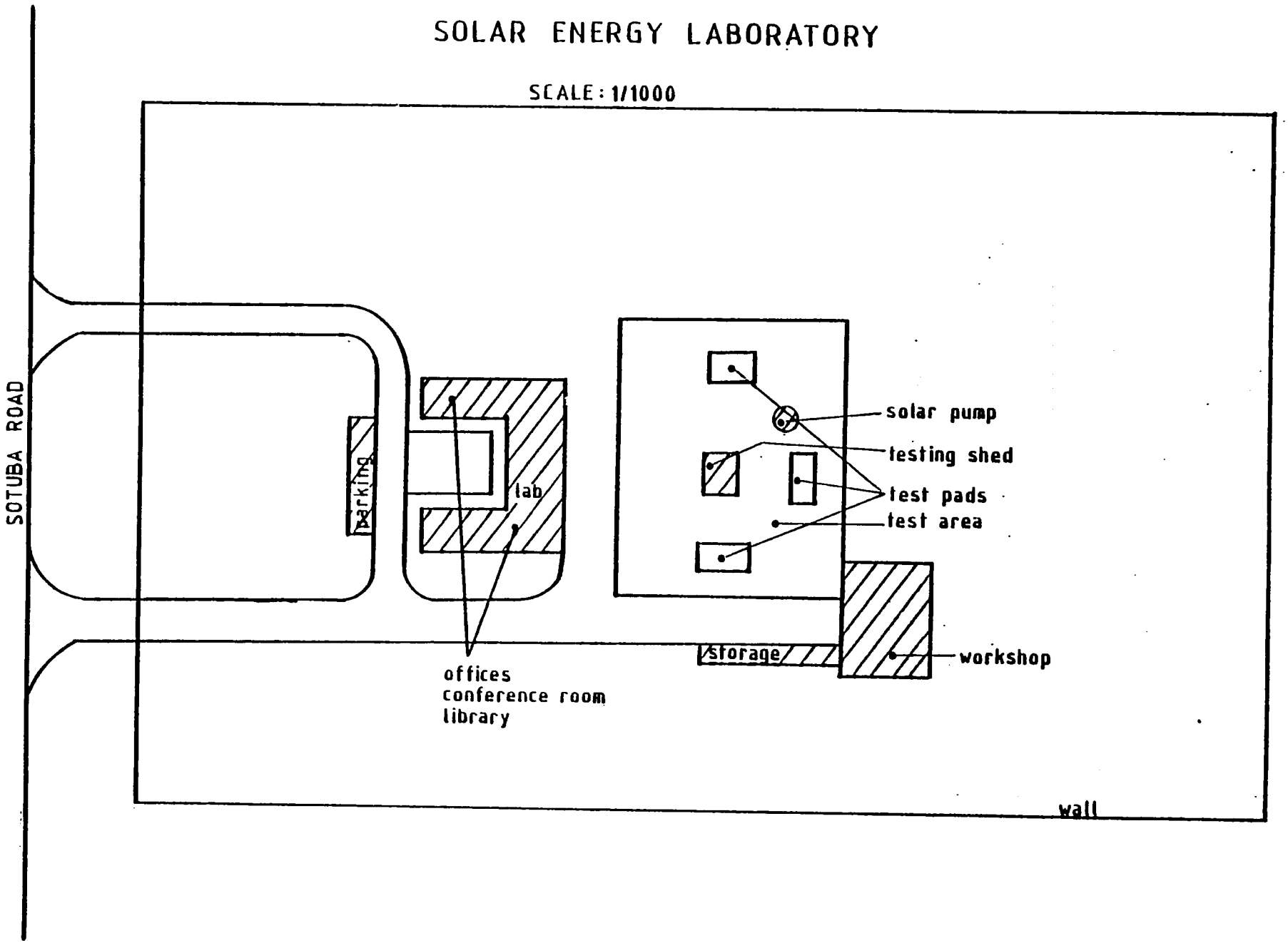
[c]$80,000 grant from UNIDO, including:

$24,000	six months of technical assistance in aluminum soldering and other production techniques
12,000	participant training in soldering (2 x 6 mos.)
3,000	study trip for Lab Director
13,000	workshop equipemnt
15,000	measuring and other equipment.
$67,000	

PRELIMINARY SKETCH - OVERALL

SOLAR ENERGY LABORATORY

SCALE: 1/1000



OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : Charles Stedman, PP Team Leader DATE: 25 May 1978

FROM : J. C. Spooner, General Engineer

SUBJECT: Visit to proposed sites for Solar Energy Lab and factory

On May 24 I visited the two proposed sites which are on the Route de Sotuba with M. Cheikné.

The factory site is 1.6 km from the city limits, about 200 meters from the road. The 125 x 200 m (2.5 ha) plot is flat and does not seem to be subject to flooding. Electric power is available from the adjacent industries supply (by the city). There is no city water or sewage system available. The water table was observed to be about 8m below the ground as there are several small wells in the area.

The plot for the solar lab and administrative office is 1,3 km farther from the city. The land is flat and treeless, size 125 x 200 m and is adjacent to the road. There does not seem to be any flooding problem. Electric power would have to come from the industrial zone 1.1 km or the Veterinary Lab which is 2 km farther out at Sotuba. No city water is available.

c.c. Jon Anderson, AID Mali
George Thompson, AID Mali
Richard Dudley, Chief Engineer REDSO/WA

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

EARLY STARTS

1. Samanko Leper Rehabilitation Village: Irrigation

Located fifteen kilometers west of Bamako on a good, well-traveled road, the village of Samanko is a rehabilitation center for former leprosy patients. Released, with their disease in remission, from the internationally renowned Institut Marchoux in Bamako, patients are sent to Samanko for rehabilitation and vocational training. Their families are lodged with them and they are provided with farmland.

Generously subsidized by the Bamako chapter of the Lions Club International, Samanko shows the effects of years of good administration. Its residents appear contented. They are well housed and fed, medical treatment is provided regularly, and they receive an opportunity to learn such income producing crafts as woodworking, cloth dying, and metal and leather working. A Catholic nursing sister is in permanent residence.

As the center's modern and well-maintained residential facilities are presently too limited for the number seeking its supportive services, two neighboring Bambara villages have been expanded to receive additional former patients. The total population in the vicinity of Samanko is about five hundred. The one hundred and fifty residents at the center itself (called Samanko I) come from all of Mali's principal ethnic groups. A weekly market held at Samanko I draws 500-600 persons.

Because of the strong support provided to Samanko and its easy accessibility, Samanko appears to be a promising site for the installation of a solar pump. Given the center's strong managerial capacity, such a pump should be well maintained. It is equally likely that it would be put to good use. In addition to providing water for human consumption and for irrigation, a solar pump at Samanko could be used by Solar Energy Lab personnel and by students at the School of Engineering and ENSUP for empirical work on PVC pumps. Samanko was in fact suggested as a potential site for an early start by a faculty member at the School of Engineering.

Samanko I has several wells which serve housing compounds and the dispensary. In 1977 Father Verspieren's well-drilling team installed a 95-meter tube well with a submersible pump at 60 meters. The pump, powered by a 15 kW diesel generator, fills two water towers. One tower is on the opposite side of the village, next to the site of the weekly market. It is

also not far from a one-hectare vegetable garden, the produce from which is consumed by village residents. The garden is currently watered by hand from open wells at either end of the plot.* The Lions Club intends to ring the garden with cut-off metal drums imbedded in the ground, linked to each other and to the water tower by a system of pipes. This would permit the village residents who tend the garden to water their vegetables, still by hand, but with considerably less difficulty.

At the far end of the vegetable plot, there is an open space. The enclosed area of the garden being too small for the demand for gardening space, a part of the open space is already being cultivated. There are also plans for planting 160 fruit trees around the outside of the garden. Further on, there is one of Samanko's two satellite villages. Unlike Samanko I, all of the houses are mud-walled.

Subject to confirmation by the Division Hydrogéologique that a suitable tube well can be installed, a potential site for the solar pump would be in the open space between the garden and the next village. If the pump's capacity were sufficient, it could serve the double purpose of irrigating the garden, including new areas brought under cultivation outside the fence, and of providing pure water for the residents of the satellite village. This may be too ambitious, but it is an indication of the possibilities that exist. In any case, the Lions Club official responsible for the Samanko project is willing and even eager to examine the possiblity of irrigating the garden with a solar pump, thereby saving the generator-driven pump for other uses.

Technical opinions will be required, however, from Hydraulique and possibly from Génie Rural as well before Samanko can be considered as definite for an early start.

2. Mopti: Irrigation

In 1977 Génie Rural requested that USAID finance the installation of photovoltaic pumps for irrigation in three different locations with the objective of comparing their performance with that of diesel pumps and a SOFRETES solar pump. Of the three requested sites, the PP team decided to choose only one - the Mopti vegetable irrigation project described below.

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*Water in these wells was observed at 11-15 meters, but they have gone dry during the dry season.

The two other sites were not recommended for the following reasons.

At Kayes, one pump had been requested for one of the area's irrigated perimeters (Moussa Guya). Génie Rural revealed to the PP team, however, that the neighboring village would prefer to use a PVC pump for human and animal needs rather than for irrigation. Since a number of village sites will be studied for pumps of this sort during Phase II of the project, and since the two early start pumps near Dilly would also provide water for consumption, the PP team decided the Moussa Guya request was not unusual or appealing enough for an early start. In addition, the difficulty in getting to Kayes is perhaps even greater than that for Dilly and Mopti. Monitoring performance during Phase I would have been difficult.

The second request that was not recommended for approval involved irrigation of the fields of the Rural Polytechnical Institute at Katibougou. The lack of attention being given to the existing pumps (one diesel and one SOFRETES) observed by the PP team, and the fact that the installed pumps were not being compared but were serving to support each other, combined to render the Katibougou request less than attractive.

The Mopti request, on the other hand, provides an opportunity to support a functioning cooperative vegetable irrigation project which needs an improved water supply. A comparison with diesel-powered irrigation can readily be conducted.

Adjacent to the city of Mopti, the 5-hectare vegetable garden is partially irrigated by a diesel pump. This pump and its 8.5 m well were installed by Génie Rural. The system has been running for three years under the supervision of the Direction de la Coopération, a government agency to promote cooperatives. This project was intended to supply the city of Mopti with vegetables (cabbages, potatoes, carrots, melons, onions, lettuce, beets, tomatoes) previously brought from Sikasso by small traders, and also to group vegetable-growing farmers in an efficient cooperative. To date only the first goal has been partially achieved. The total cost of the project, including the cost of irrigation canals was estimated by Génie Rural to be MF 3.3 million ($7,200). This amount was to be recovered by charging rent over a three-year period.

The 5-hectare irrigated area is divided into small "planches," 1.5 meters by 8 meters, that are rented out to individuals. The minimum number of planches that one can rent is 36. Some people have up to four times that

amount. The annual rental per planche is MF 660 ($1.45).

In the first year, the cooperatives agency collected only one-third of the total rent due. But the next year, with more severe measures taken, more than two-thirds was collected.

Originally only 4 ha were cultivated; the additional hectare was financed later by USAID in order to promote women's participation in the production of vegetables. There is considerable demand in Mopti for vegetables, particularly on the part of the hospital and the lycée. Efficient farmers, after paying all their operating costs, are able to earn a minimum of MF 2,000 ($4.35) per day, which is three times what a worker in the nearby fish processing plant can earn.

However, the garden has not been operating well lately. Since the beginning of the 1978 dry season, the pump has not been used. The farmers who have remained have dug their own wells at a cost of MF 2,500 per well in order to continue producing. As a result of this water-supply problem, the production of vegetables is presently very low, particularly during the dry season.

There are several reasons why the vegetable garden is not operating well.

- The additional hectare has put too much demand on the existing pump. The pump can supply 30 m^3 of water per hour, a large amount of which is lost through infiltration and evaporation.* Assuming that the pump is run 10 hours per day, the total daily supply of water is 300 cubic meters which is far less than the 500 cubic meters that is needed to irrigate the garden.

- The irrigation system, though not costly, is rudimentary and inefficient. Too much water is lost.

- The diesel pump has caused many problems; it consumes a lot of imported fuel: 10 to 13 liters of diesel fuel per day and 4 liters of lubricants per month are required.

- The price of diesel fuel in Mopti has gone up to MF 130 (28¢) per liter as of May 1978. The total cost of petroleum products exceeds MF 50,000 ($109) per month.

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*In March evaporation is as much as 254 mm per day, according to a study by the Comité Inter-africain d'Etudes Hydrauliques, Ouagadougou.

- Mopti, 645 km away from Bamako, very often runs out of petroleum products. At some periods they will be found only on the black market.
- The pump breaks down frequently.

In 1977, after the diesel pump had broken down once again, the cooperatives agency borrowed and placed in the garden a gasoline-driven pump which had been installed in a neighboring village (Niemetongo) by USAID. As a result, production costs were extremely high and the garden was unable to compete with vegetables brought in from Sikasso. (Gasoline now costs MF 180 (39¢) per liter, compared to MF 130 in 1975.)

There are other problems. In 1975 a number of civil servants, politicians and traders of Mopti were given planches. These people very often do not pay their rent. Because of their lack of interest, they have not produced as well as the more efficient professional farmers who, it is said, never fail to pay their rent on time.

The installation of a PVC pump would permit an increase in vegetable production by making more water available for irrigation, even during the dry season. Génie Rural has also requested that certain improvements be made to the existing irrigation system so as to reduce water losses due to infiltration and evaporation. Further, a storage tank for water will be required since the solar pump would produce its maximum output at mid-day, when the sun is hottest and farming most difficult. This installation should thus provide some revealing experience with a solar-powered irrigation system in a Sahelian climate. Assuming that the pump functions 6.4 hours per day and averages an hourly output of 25 cubic meters, the tank could have a capacity of 160 cubic meters and irrigate 1.6 ha. To protect the solar power system against damage by domestic animals, the construction of a fence is also suggested.

Based on its own estimates of the cost of a 1300-watt PVC pump delivered to Bamako, Génie Rural has calculated the cost of the installation as follows.

Solar pump set, c.i.f. Bamako	MF	23.00 million ($50,000)
Shipment Bamako/Mopti		0.15
Installation by Guinard		1.60
Well construction (10 m)		3.00
Storage tank		3.70
Fence		0.84
Panel footings		0.10
Civil engineering supervision		0.36
Contingencies (10%)		3.25
	MF	36.00 million ($78,300)

Génie Rural recommends that an open well rather than a tube well be installed for the pump so that farmers can draw water by hand when the solar pump is not working, because of mechanical failure or the time of day or the weather. The solar pump would be placed at one side of the open well, which would have to be quite deep to draw as much volume as the pump placed in an open well.

The item for civil engineering supervision is to cover travel costs to Mopti on the part of Génie Rural personnel. Their time will be contributed by the Malian Government.

The PP team believes that the actual cost of the pump set delivered to Bamako will be considerably cheaper than the above estimate for several reasons. First, the panels will be ordered directly from the U.S. manufacturer. With panels and associated hardware at $18 per peak watt, c.i.f. Bamako, the cost of the pump set would be $23,400 plus $7,100 for pump, motor and controls delivered from Paris, or a total of $30,500. Secondly, if the installation of the Mopti pump is timed to coincide with that of the other early starts, the cost of the Guinard expert (MF 500,000 + MF 175,000 per day x 6 days = MF 1,550,000) could be divided by four and spread among the four pumps. This possibility is the more likely since a Solar Energy Lab engineer will be trained at Pompes Guinard to supervise pump installation. The Guinard expert would thus be needed only to verify that it had been done properly and to throw the switch.

Finally, the 10 percent for inflation and contingency has been applied to the project's entire Phase I budget. The total cost can thus be estimated as:

Solar pump set, c.i.f. Bamako	MF 10.80 million	($23,300)
Shipment Bamako/Mopti	0.15	
Guinard expert	0.40	
Well construction	3.00	
Storage tank	3.70	
Fence	0.84	
Panel footings	0.10	
Civil engineering supervision	0.36	
	MF 19.35 million	($42,100)

3. Dilly: Village and Animal Water Supply (2 Sites)

In December 1977 the Malian Cattle and Meat Board (OMBEVI) requested USAID to install four solar pumps in the vicinity of Dilly, a primarily Bambara community of some 10,000 inhabitants located approximately 380 kilometers north of Bamako in the Cercle of Nara. The specific sites were: (a) Niamakabougou (or Niamabougou), a Bambara village 30 km west of Dilly, (b) Doungel, a transhumants' watering stop 2 km southeast of Dilly, (c) the OMBEVI livestock training center (C.P.E.S.) about 1-1/2 km southwest of Dilly, and (d) Kamodibo, another watering place surrounded by fields belonging to a prominent religious leader headquartered at Dilly. A fifth site, Koli -- a Sarakollé village 12 km to the east of Dilly -- was apparently considered at one time but was not included in the formal request to USAID. The Division Hydrogéologique had drilled bore holes ranging from 26 to 63.5 meters in depth at each of the suggested sites. The static water table was found to be from 17 to 27 meters deep.

At least one tube well has been installed at each site. Except for the C.P.E.S., which has a diesel generator, all are of the piston-pump airlift type with casings of 12 cm internal diameter. All sites are on gently rolling terrain and are not inundated during the rainy season. The land within 1 km and more of all well sites is overgrazed, with the exception of Kamodibo's, which is surrounded by the marabout's farmland.

When members of the PP team visited Dilly, they concluded that as long as all of the sites were considered technically feasible, early starts should be made at those two sites where augmentation of the water supply would most clearly benefit the rural majority -- at Niamakabougou and at Doungel. The former village is within a short driving distance from Dilly over a good road; regular access to it would not be difficult. An additional pump in the village would serve the needs of the Bambara residents and of the Peul and Maure herdsmen who camp nearby for part of each year and who participate with the settled farmers in a Herder's Association which has just been established under the auspices of Mali Livestock II. The site at Doungel is currently used by transhumant Peul and Maure as well as by some residents of Dilly who use it to water their stock

Of the alternative sites requested by OMBEVI, the PP team considered that the C.P.E.S. training center does not offer an opportunity to test a solar device in a representative rural setting. The Kamodibo site also seemed to offer difficulties because OMBEVI had sought a large (5 kW) solar pump supplemented by a piping system that would bring water from the well to a cattle market and slaughterhouse planned for construction near Dilly. The team was also concerned that installing a solar pump in the midst of fields belonging to one of Dilly's wealthiest and most powerful residents would not meet USAID's objective of delivering assistance to the poorest of the poor.

Further developments after the team's return to Bamako changed the picture. A representative of the Division Hydrogéologique, which was in the process of performing sustained pumping tests on its bore holes, stated that the Niamakabougou site could produce only 3.6 cubic meters per hour and that this was insufficient. OMBEVI was surprised at this conclusion and suggested that if Niamakabougou were not technically feasible two other villages in the proximity of Dilly might be substituted. These villages were (a) Demba Diawara, a village of 250-300 Sarakollé about 15 km from Dilly and (b) Fogoty, a Peul village with some 500 inhabitants that has traditionally been a rival of Dilly and is only 6 km distant. Since either one would seem to be a feasible substitute for Niamabougou, it was decided that the chief of the Division Hydrogéologique and the Malian director of the Mali Livestock II project would jointly determine which village to select. On the day of the PP team's departure, the former stated that Demba Diawara had been chosen, but as this is written a confirming telex has not yet been received from OMBEVI.

A second development consisted of strong representations on the part of OMBEVI for the replacement of Doungel by Kamodibo. It was pointed out that during the rainy season a large standing body of water develops between Dilly and Doungel. The inhabitants of the village itself, who for some time have apparently made it clear that an improved water supply for human consumption is one of their top priorities, could be expected to have to travel some distance to reach the well if a solar pump were installed at Doungel. By contrast, there is easy access at all times of year to Kamodibo, where the drilling of a borehole has revealed an excellent source of water. OMBEVI has stated that financing for a piping system

to the cattle market can be obtained elsewhere and need no longer be considered part of the request. The essential thing, in OMBEVI's mind, is to start pumping water at the Kamodibo site so that the residents of Dilly will have a much improved source of water for themselves and for their cattle. Until such time as a piping system is installed, they would apparently have no major difficulty in going to Kamodibo for water. The transhumant herds that now water at Doungel can be expected to seek out the Kamodibo well if it produces as promised.

With regard to the size of the solar pumps to be installed, it was agreed that the Kamodibo site would have one of 1300 or 1800 kW, preferably the smaller, and the village site, presumably Demba Diawara, would have one of 900 or 1300 kW, preferably the smaller. In both cases the decision is subject to a finding by the Division Hydrogéologique that the pumps would not permanently lower the water table. As indicated in the section on Environmental Concerns, the PP team believes that such findings should be confirmed by the American hydrogeologist resident at Dilly.

After the pumps are installed, OMBEVI would take responsibility for their upkeep and maintenance. It has been agreed that some form of participation on the part of villagers in the ownership, operation and maintenance of these pumps should be sought. The Mali Livestock II project is now working on the formation of village and herder associations, and OMBEVI has suggested that the project's extension agents (encadreurs) might work to involve local residents in a meaningful way. OMBEVI has a staff of Malian and French sociologists to help them in this endeavor. While the manner in which this will be worked out remains uncertain, it should be noted that the early starts by definition will be undertaken before clear answers on ownership, operation and maintenance are known. In fact, the early starts should help clarify the questions to be asked in the Phase II surveys, so that by the time the Phase III village tests are begun better answers should be available.

INSTITUTIONAL SUPPORT

1. National School of Engineering

The electro-mechanical department of the School of Engineering, under the direction of Mr. Begtine, proposes to expand present solar energy instruction, now contained within another course, to a full course which will concentrate on photovoltaic applications. The electro-mechanical department is the major supplier of engineers to the Solar Energy Laboratory. To support the School's classroom work the project would furnish both subscriptions to current periodicals and books on energy and energy-related subjects. To support its laboratory program (travaux pratiques) the project would provide modern equipment, including solar panels, in order to give the students up-to-date practical experience.

Budget

Library requirements (5 years)	$ 4,500
Laboratory requirements	
(Estimated shipping costs included)	
12 solar panels (20 W) and mounting	5,000
10-track strip chart recorder	5,000
Stock of paper for recorder	500
Sun tracking system (1 axis)	2,000
Pyranometer (global)	1,500
Oscilloscope, 2 trace with memory, low frequency	5,000
Theoretical and planning work on low-velocity windmills: equipment, supplies, in-country travel	10,000
Support for students preparing theses: in-country travel and thesis preparation costs	5,000
Total	$ 38,500

2. Ecole Normale Supérieure (ENSUP)

The personnel of the Physics Department at the Ecole Normale Supérieure appear to be doing the highest quality solar energy work in Bamako. The head of the department, Prof. Ibrahima Touré, wrote his doctor's thesis in 1973 on the calculation and measurement of solar radiation in Bamako. His measurements are the only good measurements for Mali that the PP team was able to locate.

The current programs are (a) solar refrigeration by the absorption cycle for village use and (b) concentrators applied to photovoltaic systems. The first program is Prof. Touré's personal project. He will spend four months working on it at Georgia Institute of Technology this fall. The second is a student thesis project.

ENSUP's lab was equipped by UNESCO in 1970. No new equipment has been obtained since then. Since the School's present work supports the project and because future work could be directed toward project needs, equipment and operating support is recommended as follows:

2 meter concentrator with sun follower	$ 6,000
Multi-tract strip recorder	5,000
Y recorder	4,000
Solar cell panels, 290 watts	5,000
Operating budget, books, subscriptions and future equipment needs - $5,000 per year x 5 years =	25,000
Total	$ 45,000

3. Central Veterinary Laboratory

The Central Veterinary Laboratory appears to be the institution best qualified and equipped to carry out development of a bio-digester. There is adequate space within the CVL's fenced enclosure and an adequate shop. The CVL is a short distance from the National Animal Science Research Center at Sotuba, and cow manure can be easily transported from Sotuba during the development phase. In addition, the CVL's skilled shop supervisor and engineer, Alex Ruimy, who has already built and operated a small bio-digester, is interested in directing the work.

A pit-type digester of the Gobar variety may be tried initially. An alternative is a semi-dry pit type which would make compost and gas rather than a slurry sludge and gas. The advantage of the latter is that it would use less water and the compost would be easier to apply as fertilizer.

After demonstration, the digester could be constructed in a village near Yanfoula as part of Phase III.

Budget

Pit digging, block lining, butyl rubber, etc.	$ 3,000
Mechanical construction and materials	2,000
Experimentation with changes of configuration	3,000
R & D costs during Phase II	10,000
Continuation of biogas digester development in Phase III if satisfactory progress is being made	20,000
Total	$ 38,000

4. <u>List of Suggested Institutions for Participant Training</u>

a. For the study of photovoltaics:

Solarex Corporation (Dr. Joseph Lindmayer)
1335 Piccard Drive
Rockville, MD 20850

Univeristy of Florida (Prof. Fredrick A. Lindholm)
Electrical Engineering Department
Gainesville, FL 32611

Arizona State University (Prof. Charles E. Backus)
Tempe, AZ 85281

Institute of Energy Conversion (Allen M. Barnett, Director)
University of Delaware
Newark, DE 19711

b. For the study of thermal applications:

Solar Energy Laboratory (Prof. J.A. Duffie)
University of Wisconsin
1500 Johnson Drive
Madison, WI 53706

Energy and Kinetics (Prof. H. Buchberg)
55531 Boelter Hall
UCLA
Los Angeles, CA 90024

Mechanical Engineering Dept. (Prof. K.G.T. Hollands)
University of Waterloo
Waterloo, Ontario Canada

Mechanical Engineering Dept. (Prof. Redfield Allen)
Glenn L. Martin Institute of Technology
University of Maryland
College Park, MD 20742

PHASE II SURVEY REQUIREMENTS

1. Physical Measurements

Four energy sources have been chosen for the Phase II studies. These are direct sun, wind, wood, and agricultural wastes or manure. Thus, only four types of energy source data must be gathered. In addition, wet and dry bulb temperatures are needed at certain locations. The national meteorological and/or climatological stations are sufficiently close to many of these sites that data gathering will not be necessary.

The measurement instrumentation must be simple and not too expensive. The solar duration, but not intensity, will be measured since the latter requires expensive equipment not easily operated in a village. The wind velocity will be measured using a cup anemometer which can be read at specified intervals. The availability of wood, battery, and manure supplies will be determined by survey methods in part (3) of this appendix. Following these guidelines one obtains the measurement program shown in Table H-1.

TABLE H-1

Measurement of Energy Sources

Site	Measurement	Means
Cercle de Nioro (2)	S, W, wood, B, T_D	Meteo at Nioro, survey
Cercle de Yelimané	S, W, wood, B, T_D	H, A, survey, T_D
Zone Pastorale (OMBEVI) (1)	S, W, wood, B, T_D	Climato at Dilly, survey
Villages (OMBEVI) (2)	S, W, wood, B, T_D	Climato at Dilly, survey
Cercle de Banamba (1)	S, wood, B, T_D	H, survey, T_D
Cercle de Kolokani (1)	S, wood, B, T_D	H, survey, T_D
Cercle de Kita (2)	S, wood, B, T_D	Meteo at Kita
Cercle de Bougouni (1)	S, wood, B, T_D	H, survey, T_D
Cercle de Yanfolila (1)	S, wood, B, manure, T_D	H, survey, T_D

TABLE H-1. Measurement of Energy Sources (con't)

Site	Measurement	Means
M'Pessoba (1)	S, wood, T_D, T_W, B	Climato at M'Pessoba, survey
Yankasso (1)	S, wood, T_D, T_W, B	Meteo at San, survey
Dogon Area (2)	S, wood, T_D, T_W, B	H, survey, T_D, T_W
ODEM (1)	S, wood, T_D, T_W, B	Meteo at San, survey
Kona, Sendéguê (2)	S, wood, T_D, T_W, B	Meteo at San, survey
Mênaka (1)	S, W, wood, B, T_W, T_D, B	Meteo at Mênaka, survey
Rharous II (1)	S, W, wood, B, T_W, T_D, B	H, A, T_W, T_D, survey
Diébok (1)	S, W, wood, B, T_W, T_D, B	Meteo at Tombouctou, survey
Cercle de Bourem	S, W, wood, B, T_W, T_D, B	H, A, T_W, T_D, survey
Cercle de Tombouctou	S, W, wood, B, T_W, T_D, B	Meteo at Tombouctou, survey

KEY:
- S = Hours of sunshine
- W = Wind velocity
- H = Stokes-Campbell Heliograph
- B = Batteries
- A = Anemometer
- T_D = Temperature, dry bulb
- T_W = Temperature, wet bulb

The heliograph will be a Campbell-Stokes heliograph. The village-based enumerator must change the paper each day before sunrise or after sunset and store these daily records.

The wet and dry bulb thermometers must be of a recording type, and the enumerator must remove and store the paper records.

The anemometer is of the cup type, recording, and the records must be stored by the enumerator.

In addition, comparison of the Eppley pyranometer and heliographs at

the Bamako and Tombouctou meteo stations and at the Solar Energy Laboratory will allow an estimation of global insolation from the Campbell-Stokes data.

The national stations are listed below.

TABLE H-2

List of Meteorological and Climatological Stations

Meteorological Stations	Climatological Stations
Bamako (Senou)	Ansongo
*Bamako (Airport)	Bafoulabé
Gao	Dilly
Hombori	Dogo
*Kayes	Faladjé
Keniéba	Farako
Kidal	IFAC
Kita	Kara
Koutiala	Katibougou
Ménaka	Kogoni
Mopti	Kolomboda
Nioro	Koulouba
Nara	M'Pessoba
*San	Niono
Ségou	N'Tarla
Sikasso	Sanzana
Tessalit	Sotuba
*Tombouctou	Témékou
	Zoo-IFAN

All stations measure daily temperature (dry bulb) profile and rainfall. The meteo stations measure wind velocity and direction and hours of sunshine. In addition the starred stations are starting to measure global insolation on a horizontal plane recorded at 15-minute intervals.

The equipment needed and its cost are listed in the table below.

TABLE H-3

Equipment and Cost Including Installation

Anemometer and tower	4 x 2000	$ 8,000
Spare	1 x 1000	1,000
Stokes-Campbell Heliograph	9 x 500	4,500
Spare	1 x 300	300
Recording wet & dry temperature	4 x 700	2,800
Spare	1 x 700	700
Recording dry temperature	6 x 500	3,000
Spare	1 x 500	500
	TOTAL	$ 20,800

2. Baseline Ethnographic Data

A. Survey Content and Objectives

Pre-test ethnographic surveys of potential test sites should be designed to identify those aspects of indigenous technology amenable to the introduction of small scale devices, either solar energy apparatus or innovations in traditional technology intended to foster the more efficient use of customary fuels. The surveys also should generate data on the structure and function of traditional institutions sufficient to identify those with the corporate capability required to assume managerial responsibility for the new technologies to be introduced in Phase III. The surveys should produce, as well, the baseline technoeconomic and sociopolitical information necessary to measure the results of the information necessary to measure the results of the innovations tested in Phase III, thus providing the requisite data for evaluation in Phase IV.

More specifically, the surveys should be designed to ensure provision of data on the following factors at each site. Note that this list is extensive. It will be the responsibility of the consulting social scientist to collaborate with the IER Survey Director in focusing on those sociocultural variables at each site which appear to be most relevant to the achievement of project objectives.

(1) Salient attributes of the natural setting as they relate to indigenous patterns of subsistence, e.g., soils, plant, animal, and human disease factors.

(2) Relevant aspects of recent history, e.g., place of origin, nature of relations with neighboring groups, presence or absence of a legacy of local level inter-ethnic conflict, traditional bases for inter-ethnic cooperation.

(3) Description of autocthonous patterns of subsistence technology, e.g., farming practices, livestock raising techniques, gardening, manufacture of tools and other artifacts, and craft specialization.

(4) Description of patterns of traditional economic organization, e.g., systems of land tenure and livestock ownership, the organization of work and the allocation of time, systems of distribution within the productive unit (the kin groups or associations), and within and between communities through reciprocity, redistribution, and market exchange.

(5) Social structure, e.g., organization of groups on the basis of kinship and association, especially as these relate to economic organization. Identification of the prevailing system of stratification based on sex, ethnicity, class, caste and slave status. (The relevance of this latter factor will vary with the region. It is most likely to be important in the north.) Attention should be directed to the role of such systems in determining access to productive resources, income distribution, and the acquisition of socioeconomic power.

(6) Organization of authority, e.g., means of legitimizing the exercise of power, including attention to patterns of succession and inheritance, the political sanctioning and control of property-holding relationships, the resolution of economic conflict, and the regulation of technoeconomic relations within and between communities and between the local community and representatives of the national government.

(7) Religious and magical beliefs and practices, e.g., supernatural sanctions on traditional patterns of subsistence technology and economic organization, the role of religious leaders in impeding or fostering the acceptance of technoeconomic innovations, and the effect of perceiving cause and effect relationships in magicoreligious terms upon the capacity to understand scientifically-based concepts, specifically those related to the maintenance of technical equipment and to the "rational" conduct of economic affairs.

(8) Language as it relates to problems of technical training and to written and verbal communication between ethnic groups on the one hand and with representatives of the Malian government and non-Malian technicians on the other; special attention should be given also to the potential for using the vernacular in the preparation of instructional materials and in organizing "extension" campaigns and training programs.

B. Survey Procedures

Surveys should be conducted using female and male Malian personnel educated to the ninth grade level (Diplôme des Etudes Fondamentales), provided with guides to the collection of the ethnographic survey data indicated above (see item A). Survey content and objectives should be scheduled to follow the cycle of the technoeconomic year from the preparation of the fields for planting and the movement of the herds northward, through the harvests and the beginnings of dry season specialization, to the transhumants' southward return.

All portions of the ethnographic survey should be developed in close collaboration both with IER staff and with the energy scientist. For the sake of technical and conceptual continuity both consultants should maintain contact with the project from beginning to end.

3. Baseline Economic Data

The economic survey will seek to obtain baseline data and to provide answers to important economic questions before small-scale renewable energy devices are placed in villages in Phase III. The survey design will be the responsibility of the I.E.R.'s Evaluation Unit, which has done similar studies in the past. This survey should be designed to help determine which new device would be most appropriate for testing at each location. It should estimate energy needs for a number of rural activities such as: cooking, water heating, lighting, domestic water supply and irrigation, cereal grinding, threshing, farm product drying, transportation, and communications. Since the energy needs of a small African village vary greatly depending on personal preferences, social and economic organization, climate and geographic location, it will be necessary to choose the most relevant economic data to be collected in each community under study. The outline below should thus be considered illustrative.

OUTLINE OF ECONOMIC SURVEY

a. Basic Village Data:

an estimation of:

- Village population size and demographic characteristics;
- Landholdings per family or unit of production;
- Cultivated area;
- Agricultural production and livestock holdings;
- Cash income from sources other than agriculture and livestock;
- Tax revenues collected from the village.

b. Quantitative Data on Energy Sources and Uses

Sources

1) Firewood and charcoal:

- Estimate of production and consumption per capita.
- What are the favored firewood species?
- What are the labor requirements for gathering firewood and producing charcoal?
- Firewood and charcoal prices per kilogram and a description of the channels of distribution.

2) Organic wastes:

- Estimate of the availability of organic wastes such as agricultural residues and animal manure.
- What methods of recycling organic wastes are used by family units?
- How is or could manure be collected?
- What amounts are available for collection in each season?

3) Animal and mechanical power:

- Number and type of draft animals used in the village.
- Estimate of costs of purchasing and maintaining different types of draft animal.
- Estimate of village consumption of petroleum products and breakdown of consumption by uses, e.g. lighting, farming, cereal grinding, refrigeration, transportation.
- Description of the channels of distribution for petroleum products.

4) Other:

- Estimate of battery consumption.
- Unit prices and a description of channels of distribution.

Uses

1) Cooking and Heating:

- Estimate of fuel requirements for cooking an average meal.
- Estimate of time required for cooking an average meal.
- Estimate of fuel consumed in heating a given volume of water; number of liters of heated water used per day by a typical family unit; calculation of the temperature gradient through which water must be heated for each particular use.

2) Water Supply and Irrigation:

- Estimate of the labor and other costs of drawing or pumping one cubic meter of water by current methods.
- How many liters of water does a typical family use for each type of domestic use per day (cooking, washing, drinking)?
- Estimate of animal water consumption by type.
- Estimate of the cost of irrigating one hectare by current methods if irrigation is practised.

3) Crop and Fish Drying:

- How is drying done traditionally?
- Estimate of the cost of traditional drying methods per unit of dried product.
- How much time is required to dry a unit of product?
- Estimate of spoilage under traditional methods.
- Estimate of labor requirements per unit of dried product.
- Total output and value of dried product per time period.

4) Other Uses of Fossil Fuels:

- What agricultural and other tools using fossil fuels are used by villagers?
- Estimate of costs of purchasing, operating and maintaining these tools.
- Availability of spare parts.

ECONOMIC ANALYSIS

This project would assist Mali in a five-year test for the purpose of learning whether small-scale renewable energy technologies can provide affordable and reliable alternatives to fossil-fuel technologies. As such, the project has been designed to produce information and answers to questions rather than physical output. The renewable energy devices that are to be intensively tested at 20 village sites will of course produce goods and services. Yet the significance of their output will be slight compared to the insights into their economic and social feasibility that may be expected by the end of the project.

Any cost-benefit or standard economic analysis of most of the components of this project would give negative results and be beside the point. Yet economic analysis is important to the project since one of its overall objectives is to discover which new technologies are most promising from the standpoint of cost-effectiveness. In the case of renewable energy devices other than those based on photovoltaics — such as crop dryers, improved woodburning stoves, and water heaters — there is considerable research and development work needed before they can be considered ready for village testing. Improved efficiency and the possibility of substituting local for imported materials in their fabrication may have a significant effect on costs per unit of output. It therefore seems premature to attempt an analysis comparing these new technologies with the traditional or conventional ways of doing the tasks to which they would be applied. This, in any case, is one of the responsibilities of the Phase IV evaluation.

The four "early start" photovoltaic pumps, however, are based on a perfected, if still rapidly evolving, technology that lends itself to an analysis of its present degree of competitiveness and of what is needed to make it more competitive in future.

It is clear that the PVC solar device cannot at present compete in cost effectiveness with the diesel or gasoline-powered pump. Yet it appears probable that prices of photovoltaic cells will fall sharply in the next few years. By 1984, the new technologies based on them could be quite competitive if prices of petroleum products continue to rise.

The PVC pump units to be installed as early starts under this project will in fact be cheaper than the units provided under the Mali Aqua Viva program (see pages A-4 to A-6). This is partly because of a fall in the price per peak watt and partly as a result of savings to be obtained by ordering the panels directly from the U.S. manufacturer.

From Solarex Corporation estimates, the 1978 price of solar panels and hardware delivered to Bamako is roughly $18 per peak watt. Purchase and shipment from France to Bamako of the pump, control system and motor made by Pompes Guinard cost $7,100 at most. Thus a 1300-watt solar pump set delivered to Bamako costs on the order of $30,500. By contrast, when Pompes Guniard purchases the panels and adds the associated hardware (supports and electrical connections) before shipping the complete unit by air to Bamako, the cost is $44,600. Thus as much as $14,100 may be saved by direct purchase of the panels at current prices.

Further cost savings should materialize in the near future. By 1981, early in the test phase of this project, solar panels are projected to be $5 per peak watt. Even allowing for inflation, the price of the solar panels would be $6 per peak watt just two years from now. By the year 1984 this price is expected to be down to $2 per peak watt. The initial cost of solar devices may then be low enough to make them more suitable for rural use than diesel or gasoline-powered devices, particularly when the latter's high operation costs and much shorter life span are taken into account.

An examination of the early start involving vegetable irrigation at Mopti reveals the situation in more detail. By increasing the volume of water available for the irrigation of a 5-hectare vegetable garden*, the solar pump will expand production and raise incomes of the participating farmers provided that market and price relationships are such that the increased supply does not simply trigger a more-than-offsetting fall in prices of produced vegetables. There are many secondary effects such as an improved diet for Mopti residents, negative effects on private traders who used to transport vegetables from Sikasso, increased sales for local sellers of seeds and equipment, etc. These secondary effects are not necessarily

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*For technical details, see Appendix F.

benefits or costs to the society as a whole. For example, under a ceteris parebis assumption, a fall in prices is just an income transfer from farmers to consumers and not a change in social benefits except as income distribution enters in the social welfare function. Given that it is a small-scale project, this analysis will concentrate its attention on direct effects.

It will focus on two important questions. First, under present conditions, what is the degree of competitiveness of a solar pump with respect to a diesel pump? Second, what is the net income gained by the farmers participating in the Mopti vegetable irrigation project?

To answer the first question, one needs to determine for each kind of pump the present value of the total cost of irrigating one hectare over a given period. A diesel pump that could irrigate 3.4 ha presently costs $3,500 delivered to Mopti. From Génie Rural estimates, a $6,500 well has to be built, no matter which technology is adopted. To irrigate 3.4 ha, the diesel pump has to be used 12 hours per day. Diesel fuel presently costs MF 130 (28¢)* per liter and lubricants MF 600 ($1.30) per liter. As much as 13 liters of fuel per day and 4 liters of lubricant per month are required to operate the pump. Assuming, as does this analysis, that in one year there are three production cycles of three months each, $950 (in 1978 dollars) will have to be spent each year on fuel and lubricants.

The diesel pump breaks down frequently. Its annual estimated maintenance cost is approximately $410. This figure is again in 1978 dollars. A diesel pump also has a short life span. According to some estimates, it does not last more than three years under conditions such as those found in Mopti. Others argue for five years. A solar pump lasts much longer: 10 to 20 years. This analysis will use 15 years as the life span for the solar pump.

It follows that in order to compare the two technologies, a fifteen-year project could be assumed. Under such an assumption, one solar pump would be required whereas 3 or 5 diesel pumps would have to be purchased, depending on the assumption made concerning a diesel pump's life span.

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*$1.00 = MF 460 throughout this project paper.

When diesel pumps are used over 15 years, Table I-1 gives, for different real rates of discount, the present value of the total cost of irrigating one hectare. Table I-1 assumes both five year and three year life spans for the diesel pump. Figures are in 1978 dollars. The table also shows the average annual cost given the rate of interest and the corresponding present value of the total cost.

Table I-1
(US $)

Real rate of interest in %	Diesel pump w/5 year life span		Diesel pump w/3 year life span	
	Present value of total cost per ha	Average annual cost per ha	Present value of total cost per ha	Average annual cost per ha
1	10,453	746.64	12,365	883.21
2	9,962	759.87	11,742	895.65
3	9,515	773.57	11,176	908.62
4	9,107	787.80	10,660	922.14
5	8,740	801.83	10,189	934.77
6	8,401	816.42	9,768	949.27
7	8,098	830.56	9,384	962.46
8	7,844	848.91	9,027	976.95
9	7,561	860.18	8,706	990.44
10	7,325	875.15	8,408	1,004.54
11	7,107	890.60	8,133	1,019.17
12	6,909	905.50	7,883	1,033.15
13	6,723	920.96	7,649	1,047.81
14	6,554	936.28	7,435	1,062.14
15	6,366	947.32	7,236	1,076.79

The cost of a 1300-watt (peak) solar unit delivered to Mopti can be estimated to be approximately $31,000. From Génie Rural's estimates, a 160-cubic-meter storage tank and a fence have to be built at a cost of

$9,800. The installation of a well similar to that for the diesel pump is also assumed. The maintenance cost of the solar unit should be no more than 50% of the maintenance cost of a diesel pump. This may be justified on the ground that both diesel engine and pump are subject to break downs whereas only the solar pump needs significant maintenance. There are, of course, no fuel costs.

An extra cost is added to the early starts in that the newness of the solar pumps requires the presence of an expert from France to supervise their installation.* The cost of the expert per pump, spread over four pumps, is estimated to be $850.

Summing up, the total initial cost of the solar pump amounts to $48,150. For different real rates of interest, Table I-2 gives the present value of the total cost of irrigating one hectare with a 1300-watt PVC pump over a 15 year period.

Table I-2
(US $)

Real rate of interest in %	Present value of total cost per ha	Average annual cost
1	31,887	2,277.64
2	31,774	2,423.65
3	31,670	2,574.80
4	31,575	2,731.40
5	31,491	2,889.08
6	31,412	3,052.67
7	31,343	3,214.66
8	31,277	3,384.96
9	31,220	3,551.76
10	31,166	3,723.54
11	31,116	3,899.25
12	31,071	4,072.21
13	31,029	4,250.55
14	30,991	4,427.29
15	30,955	4,606.40

* See page 6.

It can be seen from tables I-1 and I-2 that, for all positive real rates of interest, the use of solar technology is more expensive than the use of diesel technology no matter what assumption is made concerning the life span of the latter. When the real rate of interest is 1%, the solar pump costs 3 times as much as the diesel pump with a five-year life span and 2.6 times as much as the one with a three-year life span.

Further, as this real rate rises, the diesel pump becomes even cheaper compared to the solar pump. When the rate of interest rises, all future costs are lowered. Since the diesel pump, with a lower initial cost, is also the one with the higher future operating costs, the present value of its total cost per hectare decreases faster with higher rates of interest.

It would be interesting to determine, everything else held constant, what price per peak watt would make PVC pumps competitive with diesel. If one goes to the extent of assuming that solar panels were cost-free, the present value of the total cost per ha of the solar pump would be as shown below.

Table I-3
(US $)

Real interest rate in %	Present value of total cost per ha
1	20,152
2	20,398
3	20,295
4	20,200
5	20,116
6	20,036
7	19,968
8	19,902
9	19,845
10	19,791
11	19,741
12	19,696
13	19,654
14	19,616
15	19,580

*(Con't from p. 5) Pompes Guinard will train a Malian Solar Energy Lab engineer on PVC pumps in France and Corsica during the summer of 1978. He will be able to supervise the first installation, but it should be verified by a Guinard expert before the switch is thrown. For subsequent installations, no foreign expert will be needed.

When the real rate of interest is 1%, the PVC pump costs nearly twice that of the diesel pump with a five-year life span and 1.6 times that of the pump with a three-year life span. Under these conditions, a positive price could be attached to solar panels only when the real rate of interest is allowed to take negative values. This would happen only if the inflation rate were extremely high.

It thus seems clear that two events must take place before PVC pumps become competitive in a situation like that of Mopti. This would be true even if the cost of photovoltaic cells falls as sharply as is predicted. First, the cost of diesel pumps and the fuel to run them must rise substantially. Second, cost elements other than those of the pump and solar panels need to be substantially reduced. These include transportation (shipments in future will have to be by sea rather than by air) and local installations. Natural fencing or fencing of sturdy local materials will have to be substituted for imported chain-link fences, and the need for expensive storage tanks will have to be thoroughly examined. The experience gained from the Mopti pump and from other PVC pumps expected to be installed at later stages in the project should provide valuable insights as to how these costs might effectively be reduced.

The next question to be addressed, as stated earlier, is the net income gained by farmers participating in the Mopti vegetable irrigation project.

From the operation of the vegetable garden over the past three years, the Mopti cooperatives' agency has observed the following vegetable yields and prices when enough water has been available. The figures are for a three-month production cycle. Yeilds are given per square meter and average prices are in Malian Francs.

Table I-4

Vegetables	Average Yield in kg per m^2	Average Price in MF per unit
Potatoes	2.5	225
Leeks	2.5	30
Carrots	3.4	60
Onions	0.84	215
Beets	3.5	100
Cabbage	4 (heads)	200
Lettuce	30 (heads)	50

The price of each vegetable fluctuates widely over the course of a year. The price of one kilo of potatoes, for example, goes from MF 125 in January to MF 300 in June and decreases thereafter. Figures in the above table are therefore just yearly averages. Under present conditions, the Mopti vegetable garden is competing well with small traders who bring vegetables from Sikasso.

A farmer can rent a minimum of 36 "planches." This minimum is called a "parcelle." Some farmers hire one worker per parcelle. The monthly wage, excluding lodging and food that are sometimes provided, is MF7,500. Other farmers do not hire any workers, but for simplicity it will be assumed that there is one worker hired per parcelle and that the real wage remains unchanged. For each worker, MF32,400 worth of equipment (hoes, shovels, watering cans, etc.) is required. This equipment lasts about 5 years.

From the same past observations, the cost of seed per production cycle and per planche has been estimated to be MF 220 for all vegetables.

As fertilizer, farmers use manure collected not far from Mopti. For one production cycle 3 sacks are needed per planche. The price of a sack is MF100. It will be assumed that for each farmer the number of sacks will remain the same for each year and for each crop.

At the present time farmers are paying MF23,760 as annual rent per parcelle. This fixed rent serves to pay the participating farmer's share of the project's initial and operating costs.

It may be noted parenthetically that this rental payment, if every farmer pays the amount due, would be more than enough to cover the project's costs and the amortization of the pump. If the diesel pump lasted five years, the annual rental per planche would be MF443 more than needed. If it lasted only three years, the rent would be MF217 more than required. By contrast, assuming that farmers pay the same rent for portions irrigated by a solar pump, their payments per planche would be MF935 less than the amount needed to cover costs and amortization after 15 years.*

Under the above assumptions, Table I-5 gives the net income that a participating farmer can earn, per production cycle and per vegetable, from farming one planche no matter which technology is used.

Table I-5

Vegetable	Farmer's net income (MF)
Potatoes	4,885
Leeks	-995
Carrots	555
Onions	270
Beets	2,305
Cabbage	7,705
Lettuce	7,105

Except for leeks, all vegetables generate positive incomes. Cabbage and lettuce are the most profitable. If only cabbage were produced and if the total cabbage production could be entirely sold at the current price, farmers would make the maximum profit. However this is not possible. In addition to difficulties in preserving cabbage, a substantial rise in its supply would clearly result in a substantial decrease in prices. Mixing vegetables is the most reasonable assumption to make. If, for example, a parcelle owner distributes his planches as follows:

* These figures are based on a 5% real rate of interest.

cabbage	-	10
lettuce	-	7
potatoes	-	6
beets	-	5
carrots	-	4
onions	-	3
leeks	-	1
		36

he can make as much as MF 508,425 ($1,105) per year.

1. Initial Order of Equipment and Material for Existing Solar Energy Laboratory

(To be ordered in October 1978)

Item	Number	Amount ($)
Pyranometer	2	3,000
Recorder (multichannel)	1	5,000
Platinum Resistance Thermometers	4	400
Pump	1	600
Heat Exchanger	2	500
Wire		300
Thermocouple wire		500
Insulation (pipe)		200
Immersion Heaters	2	150
Flowmeters	4	2,000
Anemometer	1	1,000
Electronic Test Equipment		4,000
Connectors, cables, electronic supplies		2,000
Solar Cell Panels (10 watt)	10	1,500
Batteries, control electronics		1,500
Shop Equipment (emergency)		2,000
Material Supplies (pipe, sheet, fittings, etc.)		3,000
		$ 28,650
	Shipping	6,000
	Total	$ 34,650

2. Vehicles

a. (To be ordered in October 1978)

Item	For Whom	Number	Cost
4-wheel drive vehicle	Lab	1	$ 12,000
4-wheel drive vehicle	I.E.R.	1	12,000
4-wheel drive vehicles	survey super. teams	4	48,000
Small pick-up truck	Lab	1	10,000
4-door sedan	Lab	1	7,000
		Total	$ 89,000

b. (To be ordered in April 1979)

Item	For Whom	Number	Cost
Minibus (6-8 places)	Lab	1	$ 13,000

3. Scientific Equipment for New Solar Energy Laboratory (with shipping)

(To be ordered in April 1979)

Item	Amount ($)
Photovoltaic panels (1 kw)	$ 20,000
Batteries (lead acid) (about 20 kwh)	5,000
Controls	8,000
Pump and motor experimental equipment	8,000
Grinders	5,000
Instruments (monitoring)	8,000
Instruments (general electrical measurement)	5,000
Multi-channel recorder	6,000
Data logger	6,000
Pyroheliometer	3,000
Electrical and electronic laboratory equipment	5,000
Cabling and connectors	2,000
Computer	5,000
DC-AC converter equipment (1 kw)	4,000
Hydrograph	2,000
Anemometer registering	2,000
Oscilloscope (double track) (memory)	6,000
Tool chest & tools (test yard)	800
Flow meters (3)	3,000
Heat exchangers (2)	2,000
Insulation, piping, fittings, materials	8,000
Total	$113,800

4. Office Equipment, Furniture, and Library Materials for New Solar Energy Laboratory

(To be ordered in April 1979)

Furniture and Equipment	Quantity	Price	Source: Local or Foreign
Director's Office:			
Air conditioner	1	$1,000	F
Desk	1 on hand		-
Chairs	6 on hand		-
Bookcases	4 on hand		-
Table	1	150	L
Secretarial & Administrative Offices:			
Desks	2 on hand		-
Desks	6	1,290	L
Chairs	4 on hand		-
Chairs	4	140	L
Tables	4	600	L
File Cabinets (steel)	4	1,400	F
Air conditioners	4	4,000	F
6 Engineer Offices:			
Desks	6 on hand		-
Desks	6	1,890	L
Tables	6	900	L
Chairs	6 on hand		-
Chairs	12	420	L
Bookcases	6	1,290	L
File cabinets	6	2,100	F
Draft machine, drawing board, draft instruments	1 set	1,000	F
Typewriter, IBM electric	2	1,800	F
Texas Inst. Desk Computer	1	1,500	F
Typewriter, manual	1	300	L
Microfich reader and file	1 set	2,000	F
Library:			
* Subscriptions to Energy Journals		500	F
* Books and reference materials on energy matters		1,000	F
Bookcases	on hand		-
File cabinet	1	350	F
Tables	1 on hand		-
Tables	3	450	L
Chairs	2 on hand		-
Chairs	6	210	L
Desk	1 on hand		-
Conference Room:			
Tables	4	600	L
Chairs	12	420	L
	Total	$25,310	

*To be ordered in October 1978 with initial equipment order

5. **Prototype Workshop Equipment for New Solar Energy Laboratory**

(To be ordered in April 1979)

[Metric or DIN standards, 220 or 380 v., 50 cycle for 3 phase]

Item No.	Description	Size (or Capacity)	Qty.	Est. Cost w/20% Parts Delivered	Source: L = Local F = Import
1.	Layout tables	3 x 1.5	2	$1,000	L
2.	Tool & equip. cab.	1 x 0.6	10	750	L
3.	Work benches	2 x 0.8	5	400	L
4.	Desk & 2 chairs	1.5 x 0.8	1	125	L
5.	Shop trucks	1.1 x 0.7	4	1,200	F
6.	Sheet metal shear (manual)	132 x 1.5 mm	1	5,000	F
7.	Portable hand sheer (electric)	4.5 mm	1	600	F
8.	Power hack saw & blades	175 x 170 mm	1	3,000	F
9.	Drill press & vise & attachments	19 mm diam.	1	2,000	F
10.	Sheet metal brake (manual)	2000 x 3 mm	1	7,500	F
11.	Sheet metal roll	2100 x 4 mm	1	*	-
12.	Double end grinder w/dresser	200 (diam) x 25 mm	1	500	F
13.	Forge, manual blower, w/hood & stand	Hearth 750 x 600 mm	1	2,000	F
14.	Anvil & tools	90 kg.	1 set	1,800	F
15.	Water tank (steel)	500 x 500 mm	1	150	L
16.	Engine lathe w/ milling attachment, tools, cutters & accessories	300 x 900 mm	1 set	8,000	F
17.	Hand shear	4 mm.	1	*	L
18.	AC welder & accessories	200 A.	1	*	L
19.	DC portable welder & AC power trailer mount, diesel drive, 200 amp. w/cables & accessories & clamps				
20.	Oxy-acetylene gas cutting & welding outfit, complete, medium duty, to DIN standards		2	1,200	
21.	Portable grinder, elec., 1 HP	200 mm diam.	1	400	F

* On hand

Prototype Workshop Equipment (con't)

Item No.	Description	Size (or Capacity)	Qty.	Est. Cost w/20% Parts Delivered	Source: L = Local F = Import
22.	Spray painting set, 1.5 l. cap., 3 guns, hoses, regulators, etc. complete		1 set	1,000	F
23.	Pipe vice & stand up to 65 mm. diam. tap & die set, metric, reamers, wrenches, cutters, etc. complete		1 set	3,000	F
24.	Air compressor, operating pressure 10 bars, automatic, elec. drive 10 CFM free air cap., 3 HP		1	2,400	F
25.	Hydraulic press & pullers, manual, portable for shop & automatic work	10 ton	1	2,000	F
26.	Hand tools, sheet metal (hammers, anvils, awls, scribers, etc.)		2 sets	3,000	F
27.	Hand tools, gen. mech.		2 sets	6,000	F
28.	Hand tools, auto		1 set	2,000	F
29.	Measuring tools (scales, micrometers, dial indicator & magnetic stands. levels, protractor, straight edges)		1 set	500	F
30.	Carpenter hand tools		1 set	800	F
31.	Multiple 12 v. battery charger, trickle, auto.				
32.	Weigh scale, platform, portable, beam type	500 kg.	1	900	F
33.	Weigh sclae, bench type, beam	100 kg.		500	F
34.	Test weights	0-50 kg.	1 set	400	F
35.	Hand tools, electricians		1 set	500	F
36.	AC-DC volt ohm ammeters	0-500 v.	2	600	F
37.	Flashlight circuit tester w/holding magnet		2	30	F
38.	Volt meter tester	0-500 v.	2	70	F
39.	Chain hoist	1 ton	1	225	F
40.	Chain hoist	1-1/2 ton	1	250	F
		TOTAL		$65,300	

6. **Illustrative Budget for Fabrication and Importation of Prototype Devices for Village Testing**

a. **Local Fabrication**

3 fish dryers:	20 8' x 2' collectors @ $300 = $16,000		
	3 drying chambers = 8,000		
		24,000	24,000
30 hotwater heaters @ 500			15,000
5 refrigerators @ 1000			5,000
5 solar sills @ 200			1,000
40 solar stoves:	20 hot water @ 300 = 6,000		
	20 reflector @ 100 = 2,000		
		8,000	8,000
1,000 wood stoves (metal parts): 50 per village x 20 villages @ 20			20,000
2 biogas digesters @ 5,000			10,000

b. **Imported Devices**

8 photovoltaic pumps with water tower, piping, fence @ 50,000		400,000
10 photovoltaic battery chargers:	chargers @ 1,000 = 10,000	
5,000 rechargeable batteries @ 2	= 10,000	
	20,000	20,000
8 windmills @ 5,000		40,000
8 grinders with motor @ 3,000		24,000
	TOTAL	$ 587,000

1. List of Officials Met by Members of the PP Team

Centre Pilote d'Elevage Sahelien, Dilly

Mamadou Maiga

Warren J. Souder, hydrogeologist

Travis Voekel, Jr., livestock specialist

Central Veterinary Laboratory

M. Ruimy

Compagnie Malienne pour le Dévéloppement des Textiles (CMDT)

Réné Grimal

Direction Générale de l'Hydraulique et de l'Energie

Aly Dembélé, Directeur Général

Sitapha Traoré, Chef de la Division Hydrogéologique

Abdoulaye Ba, Chef de la Division Hydrologique

Sekou Haidara, Chef du Bureau d'Etudes

Jean-Pierre Sasmayoux, Division Hydrogeologique

Mamady Sacko, Bureau d'Etudes

Direction Nationale de l'Alphabétisation Fonctionelle et de la Linguistique Appliquée (DNAFLA)

Kalibou Tera (also attached to Centre Pedagogique Supérieur)

Guy Belloncle

Direction Nationale de la Douane

Diakité, Directeur des Services Statistiques

Direction Nationale du Génie Rural

Section Aménagements, Marc Martin

Abdoulaye Dembélé

Direction Nationale de la Métérologie

Division Agrométérologique, Demba Doucouré, Chef

Mama Konaté

Dembélé

Salim Touré

Ecole Nationale d'Ingenieurs

Moussa Maiga, Directeur

Siné Camara

Georges Begtine, head, Department of Electro-mechanical Engineering

B. Couture, professor of electronics

Ecole Normale Supérieure

Ibrahima Touré, head, Department of Physics

Energie du Mali

Woundioum Sissoko, Directeur des Etudes et des Programmes

Daouda Cissé, Comptable

European Development Fund

Detalmo Pirzio-Birolli, Resident Delegate

Institut d'Economie Rurale

Dr. N'Golo Traoré, Directeur Général

Dominique de la Croix, Chef de l'Unité d'Evaluation

Mme. Sy née Maimouna Ba, Unité d'Evaluation

Institut de Productivité et de Gestion Prévisionelle (IPGP)

Kary Dembélé, Sociologue

Moulaye Haïdara, Economiste

Laboratoire de l'Energie Solaire

Cheickna Traoré, Directeur

Amadou Doumbia, Directeur Adjoint

N'To Diarra, Ingénieur électromécanicien

Mahamane Bilaly Touré, Ingénieur thermo-physicien

Mamadou Cissé, Chef de la Section Administrative

Mamadou Lamine Touré, Ingénieur électricien

Amadou Sow, Ingénieur

Benoit Maiga, Chef d'Atelier

Mali Aqua Viva, Société Malienne de Forages Ruraux, San

Père Bernard Verspieren, Operations Manager

Père Gabriel Bourrier

Fred Bierman, mécanicien

Ministère du Dévéloppement Rural

Moriba Sissoko, Directeur de Cabinet

Amadou Touré, Chef de la Section de Dévéloppement Communautaire

Ministère de la Jeunesse, des Sports, de l'Art et de la Culture

Patrimoine Historique et Ethnographique

Josef Coulibaly, Directeur

Mopti

Chef de Bataillon Danfaga, Gouverneur de la 5ème Région (Mopti)

Sidibé, Conseiller Economique, Gouvernorat

Sidibé, Directeur de la Coopération Nationale, Mopti

Mopti (con't)

Doré, Agronome

Bayou Djanepo, President de la coopérative des pêcheurs

Zandiagou Sanago, Conseiller economique, Coopérative des pêcheurs

Office Malien du Bétail et de la Viande (OMBEVI)

Dr. Boubacar Sy, Directeur General

Dr. Almouzar Maiga

Dr. Ousmane Guindo, Chef de la Division Production Animale

Bokary Diarra

Dr. Gabriel Rieusset

Yves Dominoni

Samanko Rehabilitation Center

Jamil Souccar

Société d'Exploitation des Produits Arachidiers du Mali (SEPAMA)

Roland Hainer, Director of the Kita peanut oil mill

U.S. Peace Corps/Mali

Henry Homeyer, Director

Dague Clark, Deputy Director

Roy Cole, Volunteer, N'Gara

Charlotte Crystal, Volunteer, Sama

David Mattern, Volunteer, Sama

Others

Commandants de Cercle at Dioila, Koulikoro and Tominian

Club du Sahel consultants

Eric T. Ferguson

Bernard Meunier

Hans Schöner

Gilles Réné-Bazin, Manager Solar Cell Pump Department, Pompes Guinard, France

Abdoulaye Sidibé, Chief of project at Katibougou

Kassoum Koné, graduate of Ecole Nationale d'Ingénieurs who did a a thesis on wind power and now works at the E.M.A.B. furniture factory

Malians Who Have Worked on Solar and Other Alternative Energy Sources But Were Not Previously Identified

Amadou Baba Diallo, Ecole de Medicine	worked on solar energy
Abdulai Dramé	worked on photovoltaics at ENI
Lassana Keita	worked on photovoltaics at ENSUP
Balla Moussa Traoré, docteur du 3ème Cycle, physis	worked on photovoltaics
Mamadou Lamine Touré (not the same as the Lab engineer)	did a thesis on photovoltaics

2. Participants in the Joint Mali-USAID Meeting of May 29, 1978

MM.	Aly	DEMBELE	Hydraulique
	Solomani	DIAKITE	Hydraulique
	Souleymane	DEMBELE	Hydraulique
	Abdoulaye	BA	Hydraulique
	Abdoulaye	TANGARA	Hydraulique (Opération Puits)
	Cheickna	TRAORE	Laboratoire de l'Energie Solaire
	Amadou	DOUMBIA	Laboratoire de l'Energie Solaire
	N'To	DIARRA	Laboratoire de l'Energie Solaire
	Mahamane B.	TOURE	Laboratoire de l'Energie Solaire
	Mamadou L.	TOURE	Laboratoire de l'Energie Solaire
	Mamadou	CISSE	Laboratoire de l'Energie Solaire
	Bokary	DIARRA	OMBEVI
	Ousmane	GUENDO	OMBEVI
	Yves	DOMINONI	OMBEVI
	Ousmane Said	CISSE	D.N.A.F.L.A.
	Adama	OUANE	D.N.A.F.L.A.
	Guy	BELLONCLE	D.N.A.F.L.A.
	Gaoussou	KEITA	Opération Arachide et Cultures Vivrières (OACV)
	Moussa	MAIGA	Ecole Nationale d'Ingénieurs
	Amadou	GOLOGO	Meteorologie Nationale
	Mama	KONATE	Meteorologie Nationale
	Woundioum	SISSOKO	Energie du Mali
	Mahamady	DEMBELE	Direction Agriculture
	Zoumana	BERTHE	Animation Rurale (Radio-Mali)
	Guillaume	DIALLO	Eaux et Forêts
	Jon	ANDERSON	USAID/Mali
	Clarence	KOOI	USAID PP Team
	Peter	HAMMOND	USAID PP Team
	Youssouf	SYLLA	USAID PP Team
	Charles	STEEDMAN	USAID PP Team

Agencies Invited but not in Attendance:

Génie Rural

Opération Pêche

Institut d'Economie Rurale

Direction Générale de la Santé

Opération Haute Vallée

C.M.D.T.

Union Nationale des Femmes du Mali

PROJECT DESCRIPTION FOR GRANT AGREEMENT

The basic purposes of this project are (a) to improve the quality of life in Mali, particularly in the rural areas, by energizing tasks that are now largely accomplished by human muscle power, and (b) contribute to the alleviation of Malian dependence on increasingly costly fossil fuels and firewood with its negative economic and ecological consequences. A third purpose is to gain a better understanding, based on close observation of experience, of the technical, social and economic consequences of introducing renewable energy technologies in rural Africa.

To accomplish these goals, the project proposes a coordinated program — involving up to eight Malian agencies -- of institutional support, applied research and development, village surveys, and field demonstrations at over twenty sites. In sum, the project aims to prepare Mali to introduce renewable energy technologies in rural areas on a wide scale.

Two types of preparation will be required. There must first of all be a sustained effort to adapt proven technologies to the Malian situation. The substitution of local for imported materials used in the fabrication of various devices will be as important as making design modifications that increase durability under Malian conditions. Secondly, efforts must also be made to determine effective ways for village groups or family units to take over the ownership, operation and basic maintenance of the new devices. Both types of preparation will have to be successfully completed for each new technology before it will be possible to consider it for wide scale distribution to villages, not only in Mali but possibly elsewhere in the Sahel.

The Malian organization which will have responsibility for the technical phase of the program will be the Solar Energy Laboratory, a Division of the Directorate General for Water Resources and Energy, Ministry of Industrial Development and Tourism. Several Malian organizations will be involved in the rural survey and applications aspect of the program, with the Evaluation Unit of the Institute of Rural Economy playing a key role. Accordingly, to assure a coordinated effort, the Government of Mali will establish a project committee, headed by the Director General for Water Resources and Energy, which will have responsibility for such coordination.

The project is comprised of five phases: Phase I (institutional support and early starts), Phase II (village level surveys), Phase III, (village level testing), Phase IV (evaluation), and Phase V (dissemination of results). It is understood and agreed that, prior to the initiation of Phase III, an evaluation will be conducted by a team of energy scientists and that a decision to proceed to Phase III will be subject to the mutual agreement of both parties that the project is ready to proceed to Phase III. It is also understood and agreed that Phase V of the project, if it is undertaken, will require additional analysis and funding and will therefore be subject to an amendment to this agreement.

Phase I

(a) Early Starts

In order to provide a momentum and demonstration effect for the program, and to gather valuable information for its subsequent phases, four early starts are contemplated. Each will consist of small pumps powered by arrays of photovoltaic cells. Two will be installed in the Dilly area under the auspices of OMBEVI, one in Mopti, under the auspices of Génie Rural and a fourth at the leper rehabilitation center at Samanko. In addition to operating and maintaining these devices, the sponsoring institution will also be responsible for gathering technical and socio-economic data in accordance with arrangements to be worked out between the parties to this agreement.

(b) Institutional Support

This element of phase I will consist of major support to the Solar Energy Laboratory for its applied research and development program. In addition, complementary assistance will be provided to the National School of Engineering, the Ecole Normale Supérieure, and the Central Veterinary Laboratory in accordance with the provisions and funding noted in the project agreement budget.

Support for the equipment and facilities of the Solar Energy Lab, as noted in the budget, is aimed at initiating a program of applied research for perfecting certain renewable energy technologies for use in Mali. This program will be started immediately upon signature of the project agreement and priority will be given to the procurement of the initial order of machine tools and scientific equipment noted in the budget and attached equipment list.

Tentative priorities for the Lab's research and development program, as worked out in pre-project discussions, include (a) testing and improvement of solar water heaters for urban uses and rural institutions (dispensaries, schools, etc.), (b) testing and improvements on crop/fish dryers, (c) development of an efficient, wood-burning stove using readily available materials, (d) development of an efficient photovoltaic battery charger, emphasizing reliability and ease of operation. Other priorities may be added to the list in the course of phase II and as the Lab develops the capacity to take them on.

Phase II

The second phase, eighteen months in duration (including a preparatory period), will begin six months from the initiation of phase I and will involve coordinated activity directed by the Rural Economic Institute (IER) with the participation of the other government agencies represented on the project committee. During phase II meteorological and socioeconomic studies will be undertaken at 25 villages determined (by the project committee) to have potential for experimentation with devices using alternative energy sources. The studies will be planned by IER and an American social scientist (provided by the project) and an engineer designated by the Lab who will be its liaison with the field studies. Initiation of the studies will be preceded by a training program for the enumerators (2 to each village) and for four mid-level supervisory teams, each of which will cover a specific geographic zone and periodically visit the village sites in its zone. These teams will consist of a Malian controleur and a Peace Corps Volunteer (or U.S. graduate student) both appropriately trained in survey techniques.

In addition to the collection of data, a crucial aspect of phase II will be the selection of village cadre who will later assume responsibility for the operation and maintenance of the device or devices to be installed. Selection of the cadre will be a function of village preferences, interaction with the supervisory survey teams, and the characteristics of the devices to be introduced.

The major output from phase II will be village level reports indicating (a) socioeconomic base-line data, (b) availability of local energy sources (wind, insolation, biomass, etc.), (c) village preferences as to

tasks to be energized, and (d) potential village capacity to operate and maintain energy devices. At the end of Phase II, 20 of the most promising of the 25 villages surveyed would be selected by the project committee for the introduction of energy devices in Phase III.

Prior to the initiation of the third phase, a rigorous review and evaluation of the research and development work of the Lab will be conducted by a team of three energy scientists. The review will focus on whether the measuring, testing, and modifications work performed by the Lab was good enough to assure confidence that its renewable energy devices could be tested in the field.

If the review is predominantly negative or mixed, Phase III will be delayed and Phases I and II extended until appropriate modifications are made and completed. The point is that village testing will not occur until the devices are considered to be ready for field application.

Phase III

In Phase III, which will last 2 1/2 years, several different devices and applications will be tested in the villages selected. Performance will be watched with some care, and the social and economic changes that result from the introduction of the new technology will be observed and recorded. One of the Solar Energy Laboratory engineers will direct the project in this testing phase. The Lab itself will continue to make adjustments to the devices being tested as experience is gained during phase III.

Operation and basic maintenance of the devices will be carried out by the village cadre. They will receive technical support from the Solar Energy Laboratory. In addition, the data-gathering network will continue to function, with one enumerator observing and recording socioeconomic data at each village site. The supervisory teams will continue to make periodic visits. This work will be reinforced by the continued guidance and consultant services being provided by IER, a consulting U.S. energy specialist, and the consulting social scientist.

Phase IV

The fourth phase of about six months will be devoted to a detailed analysis and evaluation of the experiments. Base data collected during phase II before the devices were introduced will be compared with data collected after more than two years of use of the new technology. The

evaluation will attempt to determine whether the project had provided answers to the following questions:

1. Which technologies are most susceptible to local operation and maintenance and, in each case, how should local control be organized?

2. What will be the impact of the new technology on income levels, income distribution and social welfare in the community? Who benefits the most? the least? not at all?

3. Which devices perform and endure well in their physical setting?

4. How do the costs per unit of output compare with alternative sources of energy that could be used in the same setting?

5. Are the technologies culturally and socially acceptable to those who use them, or do they require changes in habits that are considered unacceptable?

The evaluation will take place under the joint direction of the IER Evaluation Unit and the Solar Energy Lab's project director and will utilize the outside consultants who had been involved since the beginning, supervisory personnel, DNAFLA, and such others as may be able to contribute in the light of the situation at the time. A six month effort to compare the village sites before and after the tests, with full exploration of the performance of the devices, the villagers' adaptation to them, and the socioeconomic changes induced, will be required. An evaluation report will be translated, printed and distributed.

Phase V

As the results of the evaluation begin to emerge, a fifth phase will be considered. Phase V would consist of transitional support to the Solar Energy Laboratory. The project would seek to collaborate with other donors in promoting proven devices for private sector production and distribution, in both urban and rural areas. It would be desirable to set up licensing arrangements so that the Lab would receive royalties from the sale of these products and thereby finance further research and development activities. Phase V would be developed in greater detail during the later years of the project and funding for its implementation would be added through a project agreement amendment during the fifth year.

JOB DESCRIPTIONS

1. CULTURAL ANTHROPOLOGIST OR SOCIOLOGIST

Education: Ph.D. in cultural anthropology or sociology with an emphasis on African studies.

Experience: Research and/or teaching experience in economic anthropology or development economics. Previous fieldwork in Francophone Africa, preferably in the Sahel.

Qualifications: Research and writing ability demonstrated by a good publication record. Ability to speak and read French well. Excellent health.

Responsibilities: Collect available background ethnographic documentation and prepare ethnographic profile reports on the principal groups to be affected by the project, especially on the Bambara, Malinké, Peul, Sarakollé, Dogon, and Sonrai.

Design baseline ethnographic surveys relevant to achieving an improved understanding of the structure and function of the indigenous institutional matrix into which new technologies will later be introduced. Oversee the collection of baseline technoeconomic data against which project results can later be measured.

Collaborate with the Energy Scientist, the Survey Director and the Solar Energy Lab Project Director in all aspects of the survey, testing, and evaluation phases of the project and in preparation of the appropriate portions of all project reports.

Conduct a pre-survey seminar for supervisory personnel. Assist in the organization of mid-survey and post-survey conferences.

Ensure maximum feasible collaboration with Malian institutions and Malian scholars with relevant research experience.

Availability: The cultural anthropologist/sociologist should be able to spend 4-6 months of his or her time on the project in Phase I, including one trip to Mali around April or May 1979. In Phase II he or she would be expected to spend three months on the project and make three trips: one in September 1979 for the survey training program, one at the mid-point in the survey and a third in October/November 1980 at the end of the survey. In Phase III there would be six months' of effort spread over 2 1/2 years and six trips to Mali. In Phase IV (April-September 1983) he or she would be asked to devote three months to the evaluation of the entire project and to make two trips to Mali.

2. RENEWABLE ENERGY ENGINEER OR SCIENTIST

Education: B.S. to Ph.D. in physics, mechanical engineering, electrical engineering, applied physics, engineering physics or solar engineering.

Experience: Must have worked closely with testing and analysis of solar thermal devices such as flat-plate collectors, dryers, stills, and with the measurement of insolation.

Qualifications: Must have good command of French. Must be able to work effectively with a group of engineers, the Solar Energy Laboratory Director and other Laboratory personnel. Must have managerial ability and teaching ability.

Responsibilities: Assist the personnel of the Solar Energy Laboratory in setting up a new laboratory. Assist with planning the details of engineering measurements, purchasing the equipment and putting it into operation, writing operating procedures, instructing personnel, analyzing results and writing reports. Assist in the development of solar devices such as flat-plate collectors, water heaters, dryers, stills and photovoltaic battery chargers. Collaborate with Lab personnel, the Survey Director and the Cultural Anthropologist in the conduct of the survey, the analysis of its results, and preparation of the report.

Availability: The renewable energy engineer/scientist would spend two years in Mali on assignment to the Solar Energy Laboratory, beginning in February 1979 or earlier if possible. As indicated, the individual would be able to participate in the technical aspects of the Phase II survey, the analysis of its results and the preparation of the report, which would be issued around April 1981. If the energy engineer/scientist has performed capably, it would be highly desirable to have him or her continue to be associated with the project as the renewable energy consultant. The consultant would be expected to spend up to six months on the project in the remainder of Phase III (March 1981 - March 1983), making up to six trips to Mali in that period. In the final evaluation phase, (April - September 1983), the consultant would be asked to spend 2 1/2 months on the project and to make two trips.

Waiver: A waiver, if necessary, is requested to allow for the recruitment of qualified technical assistance personnel from outside the United States.

Justification: The PP team scientist believes that it may be difficult to find a qualified American alternate energy scientist who speaks French and who would be available for the required period of time. If this turns out to be the case a waiver is requested to recruit personnel from outside the U.S., possibly in Canada or in France.

PROCUREMENT PLAN

1. Responsible Agency

All procurement under this Development Grant will be the responsibility of USAID/Mali.

2. Procurement Services Agent (PSA)

In view of the variety of American products required for the project and the high dollar value of the procurement in the United States (Geographic Code 000), the Solar Energy Laboratory will appoint a professional PSA to undertake the necessary purchases. It is expected that a procurement services contract will be negotiated with the Afro-American Purchasing Center (AAPC), One World Trade Center, New York, New York, 10048. This appointment of a procurement services agent will be finalized within thirty (30) days after the signing of the Grant Agreement.

AAPC is fully qualified to act as a PSA and has AID's approval to perform in this capacity. AAPC's fee is negotiable and will be determined prior to any procurement being undertaken.

If the host government so requests, the USAID/Mali and/or any other United States Government agency is eligible and qualified to act as the project PSA.

3. Equipment/Commodity List

The items listed under this heading are those that represent the general needs of the project over its five (5) year life span. More exact details and specifications will be furnished in the Project Implementation Orders/Commodities (PIO/Cs), which will be issued to enact procurement.

4. Source of Procurement

The source and origin of commodities being procured for this project will be the United States (Geographic Code 000) except as authorized under waivers or exempted as shelf items purchased under sanctioned local currency procurement. For purposes of this Grant, items procured in the host country having their verifiable origin in the United States will be considered to be of U.S. source and eligible for financing.

5. Dates of Procurement

All procurement actions will be taken subsequent to meeting the normal conditions. Efforts will be made to have the speediest delivery to Mali of the following high-priority commodities:

a) Initial order of Laboratory Equipment

b) 4 "early start" solar pumps

The PSA will be notified of the priority of need for these items, and will be expected to procure and deliver them to Mali within six (6) months after receipt of a PIO/C; if this delivery is not feasible, the agent must notify the Grantee and USAID/Mali of his inability to meet the delivery date and recommend a more feasible and appropriate time.

6. Shelf Item Procurement

Imported shelf items having their origin in the United States (Geographic Code 000) can be purchased without restriction, except for the limitation on the total amount available for local procurement.

Shelf items having their origin in Geographic Code 941 countries are eligible for local cost financing in unlimited quantities, save for the limit on local procurement funding.

Shelf items having their origin in Geographic Code 935 countries are eligible for local cost financing if the unit cost does not exceed $5,000 and the total of such financing does not exceed 10 percent of the total local costs financed by USAID or $10,000, whichever is higher.

Commodities mined, produced, or assembled in Mali are available for purchase without restriction, except for the limitation upon the total value of local procurement established in the Agreement.

Procurement of imported shelf items shall conform to good commercial practices, shall be at reasonable prices, and shall be consistent with local laws and practice.

A supplier furnishing shelf items for the project must provide a statement attesting to the source and origin of the commodity sold. The USAID Director, in turn, must attest that the price being paid is a reasonable one.

7. Local Currency Procurement

To support activities of the project, local currency authorization will be required to purchase the goods and services indicated:

Workshop equipment (see "L" items, Appendix J(5))	$ 3,000
Office equipment and furniture (see "L" items, Appendix J(4))	9,000
Local training	20,000
Village survey and tests	584,000
Laboratory construction	350,000
Lab R&D, operating costs	250,000
Fabrication of test devices	186,000
Vehicles	102,000
Report preparation, translation, printing	42,000
Contingency and inflation	337,000
	$ 1,883,000

8. Waivers

A. A waiver of the source and origin restriction on purchase of motor vehicles is requested to permit the purchase of the following items.

1	4-door sedan	$ 7,000
6	4-wheel drive vehicles	72,000
1	small pick-up truck	10,000
1	minibus (6-8 places)	13,000
		$ 102,000

Justification

This authorization is needed to allow the grantee to implement and supervise the project effectively. The project calls for studies of potential sites and installation of alternate energy devices in remote areas of Mali. During much of the year most of these areas are accessible primarily by animal-drawn transport or by four-wheel drive vehicles. Rural roads consist of rugged unimproved tracks in desert sand conditions and flood plain areas interspersed with bogs and marshes. It has been the experience of the USAID/Mali program that Landrover and Toyota type vehicles are the only ones capable of being maintained and serviced adequately enough to meet transport requirements in areas where the project will be implemented. In addition the Mission thus far has had successful experience operating these types of vehicles under the strenuous conditions called for in the proposed project.

At the same time, experience in Mali has revealed that U.S. four-wheel drive vehicles cannot be used effectively because of the unavailability of spare parts and the lack of experience in the use and maintenance of these vehicles in Mali. American manufacturers, distribution and service firms have only recently begun to take a tentative and still insignificant look at entering the Malian market. While this situation might change over the long term, a much more sizable and widespread penetration by American vehicle firms into the Malian market is needed to assure that reliance on American vehicles is in the best interests of this project and of the GRM, which will be using these vehicles after AID participation is completed. It is conceivable that harmful political consequences might arise if motor vehicles financed by the United States cannot be used effectively by the GRM over a normal useful life.

We conclude, therefore, that four-wheel drive and other motor vehicles which are essential to the successful implementation of the project, are not available in an effective manner from the U.S. or other presently eligible sources. The GRM does not have the foreign exchange to procure vehicles from the other sources, nor are other donors interested in providing funding for such a purpose because of their heavy involvement in other sectors or in other geographic areas of Mali.

For these reasons, special circumstances exist within the definition of Section 364 of the Foreign Assistance Act of 1961 which in our judgment justifies a waiver of the Section's procurement restrictions with respect to motor vehicles required for the subject project. In addition it is necessary to authorize procurement of the motor vehicles described above from Geographic Code 935 countries because the exclusion of procurement from these sources would seriously impede the attainment of U.S. foreign policy objectives and the objectives of the foreign assistance program.

The probable source of these vehicles will be the United Kingdom, France or Japan.

B. A waiver of the source and origin restriction commodities is requested to permit the purchase of the following items.

5 Guinard Alta-X pumps (including shipment, assembly, installation and ancillary structures)	$ 275,000

Justification

At the present time the French company Pompeo Guinard is the only reliable supplier of water pumps adapted for use with solar (photovoltaic) panels. Although the solar panels are manufactured in the U.S., the U.S. does not now market a proven pump that can be powered by these panels. Guinard is currently working with an American solar panel manufacturer, Solarex Corporation of Rockville MD, to find a suitable pump manufacturer in the U.S. who could produce Guinard pumps under license. This would enable U.S. Government organizations to procure solar pumps without waivers.

At the present time, while it will be necessary to seek a waiver for the pumps, it appears possible for purchase of the solar panels and their ancillary hardware directly from Solarex Corp. The manufacturer would ship the panels directly to Mali, where they would be hooked up to Guinard pumps and installed under the guidance of a Guinard expert. Since the panels represent more than 75% of the cost of the entire pump set, the amount of the waiver required may in fact be considerably less than the figure indicated above. Because Guinard is now working exclusively with Solarex Corp. in the U.S., a sole source procurement waiver for the panels may, however, be necessary.

Solar water pumps are an important and promising element of alternate energy technology and of this project. If the price of solar panels falls as expected, these pumps are likely to become a viable alternate to fossil-fuel or traditionally powered pumps. This is a very important concern for the countries of the Sahel and especially landlocked nations such as Mali, which pay heavily for the fuel they use. It is essential to the success of this project that this technology be included and tested. It is conceivable that the exclusion of this technology from the project could have harmful political consequences. Such an exclusion may be interpreted as a lack of commitment to the project and to aiding Mali develop its alternative energy potential.

It is necessary to authorize procurement of the equipment described above from Geographic Code 935 countries because the exclusion of procurement from these sources would seriously impede the attainment of U.S. foreign policy objectives and the objectives of the Foreign Assistance Program.

C. A waiver is requested in order to permit local architectural and construction services and construction materials to be used for the Solar Energy Laboratory.

Construction costs $ 350,000

Justification

Past experience has demonstrated that a construction element of the size contemplated here is not large enough to attract qualified U.S. firms. The cost of mobilization for a U.S. firm is prohibitive and makes these firms non-competitive with local firms. Therefore a waiver is necessary to allow for the use of qualified local architectural and construction services and of local construction materials.

9. Payments

Payment to the PSA for services rendered will be made by the Direct Letter of commitment method; upon receipt of the PIO/C in AID/W (SER/FM/BFD), the Letter is sent to AAPC to initiate procurement. When AAPC has completed its purchasing actions, documents are presented to the AID Controller's office in New York City, New York for payment.

Local procurement payments will follow regular procedures as dictated by the Controller, USAID/Mali, who will effect payment after verification of appropriate documents.

10. Delivery

All project commodities imported into Mali will be shipped on the basis of CIF Bamako. Suppliers will provide all-risk marine insurance in the amount of 120% of the CIF cost of the commodities and similar insurance for inland freight. AID's marking requirements for overseas shipments will be enforced by the PSA.

11. Receipt and Utilization

The Grantee is responsible for the proper reception and clearances of incoming project commodities, with the assistance of the USAID/Mali staff. Inspections of incoming shipments must be made, and receiving documents shall be annotated with comments on evident or possible damages/losses.

Reports of damanges/losses must be made promptly. If incoming cargo has been procured in the United States, AAPC must be notified by telegram of the extent of the damages/losses so that AAPC can file a "notice to file a claim" against the ocean carrier or freight forwarder(s) involved. Once AAPC has filed its notice, the carrier must await the filing and adjudication of the claim. This permits the Grantee and USAID/Mali personnel to acquire more information and particulars about the claim. In most cases where damages or losses are noted, a picture of the broken box or damaged crate or crushed vehicle roof is the best possible evidence that can be presented. Receiving documents, properly annotated, are valuable. If damages or losses are not noted on the documents, however, there would be little or no possibility of having a claim settled.

Grantees are required to put into project use all commodities procured for the project within one (1) year of receipt; the local AID representative (USAID/Mali) will inspect the Grantee's utilization reports as a matter of course.

12. Marking

The Solar Energy Laboratory and all participating agencies will be made aware of USAID standard marking requirements.

APPENDIX O

6C(2) - PROJECT CHECKLIST

Listed below are, first, statutory criteria applicable generally to projects with FAA funds, and then project criteria applicable to individual fund sources: Development Assistance (with a sub-category for criteria applicable only to loans): and Security Supporting Assistance funds.

CROSS REFERENCES: IS COUNTRY CHECKLIST UP TO DATE? IDENTIFY. HAS STANDARD ITEM CHECKLIST BEEN REVIEWED FOR THIS PROJECT?

I. GENERAL CRITERIA FOR PROJECT.

1. App. Unnumbered; FAA Sec. 653(b)

(a) Describe how Committees on Appropriations of Senate and House have been or will be notified concerning the project; (b) is assistance within (Operational Year Budget) country or international organization allocation reported to Congress (or not more than $1 million over that figure plus 10%)?	Within OYB
2. FAA Sec. 611(a)(1). Prior to obligation in excess of $100,000, will there be (a) engineering, financial, and other plans necessary to carry out the assistance and (b) a reasonably firm estimate of the cost to the U.S. of the assistance?	See 611a Certification in PP
3. FAA Sec. 611(a)(2). If further legislative action is required within recipient country, what is basis for reasonable expectation that such action will be completed in time to permit orderly accomplishment of purpose of the assistance?	No further legislative action or approval is necessary
4. FAA Sec. 611(b); App. Sec. 101. If for water or water-related land resource construction, has project met the standards and criteria as per Memorandum of the President dated Sept. 5, 1973 (replaces Memorandum of May 15, 1962; see Fed. Register, Vol 38, No. 174, Part III, Sept. 10, 1973)?	N/A
5. FAA Sec. 611(e). If project is capital assistance (e.g., construction), and all U.S. assistance for it will exceed $1 million, has Mission Director certified the country's capability effectively to maintain and utilize the project?	Yes. See 611e Certification in PP

6. FAA Sec. 209, 619. Is project susceptible of execution as part of regional or multilateral project? If so why is project not so executed? Information and conclusion whether assistance will encourage regional development programs. If assistance is for newly independent country, is it furnished through multilateral organizations or plans to the maximum extent appropriate?

The Solar Energy Lab has received assistance in the past from both CIMADE and UNIDO. However their assistance has been oriented towards production instead of applied research. It is foreseen that at latter stages of project development when perfected prototypes exist other donors might participate in a production phase. Outputs of this project should be valuable for other countries in the Sahelian Region. An important element of this project is increasing the coordination and information flow among Sahelian Solar Energy Institutions and international organisations.

7. FAA Sec. 601(a); (and Sec. 201(f) for development loans). Information and conclusions whether project will encourage efforts of the country to: (a) increase the flow of international trade; (b) foster private initiative and competition; (c) encourage development and use of cooperatives, credit unions, and savings and loan associations; (d) discourage monopolistic practices; (e) improve technical efficiency of industry, agriculture and commerce; and (f) strengthen free labor unions.

7. It is anticipated that the project will strengthen village level organisations which manage the alternate energy source devices. Decentralised improved technology is a major goal of the project. The applie research program will increase the efficienc of the technology.

8. FAA Sec. 601(b). Information and conclusion on how project will encourage U.S. private trade and investment abroad and encourage private U.S. participation in foreign assistance programs (including use of private trade channels and the services of U.S. private enterprise).

8. The US is at the forefront in most areas of alternate energy source development Most purchases will be made in the U.S. and private U.S. participation in this program will be substantial. Technical assistance required under the project will come from the U.S.

9. FAA Sec. 612(b); Sec. 636(h). Describe steps taken to assure that, to the maximum extent possible, the country is contributing local currencies to meet the cost of contractual and other services, and foreign currencies owned by the U.S. are utilized to meet the cost of contractual and other services.

9.

10. FAA Sec. 612(d). Does the U.S. own excess foreign currency and, if so, what arrangements have been made for its release?

10.

B. FUNDING CRITERIA FOR PROJECT

1. Development Assistance Project Criteria

a. FAA Sec. 102(c); Sec. 111; Sec. 281a. Extent to which activity will (a) effectively involve the poor in development, by extending access to economy at local level, increasing labor-intensive production, spreading investment out from cities to small towns and rural areas; and (b) help develop cooperatives, especially by technical assistance, to assist rural and urban poor to help themselves toward better life, and otherwise encourage democratic private and local governmental institutions?

To a large extent development depends on energy production. The project is a test of alternate small-scale rural energy device The rural poor will be directly involved in the management and upkeep of the devices and they will benefit from increased local energ production. Organisations and cooperatives managing the devices will be strengthened through training and experience with the energy devices.

b. FAA Sec. 103, 103A, 104, 105, 106, 107. Is assistance being made available: [include only applicable paragraph -- e.g., a, b, etc. -- which corresponds to source of funds used. If more than one fund source is used for project, include relevant paragraph for each fund source.]

(1) [103] for agriculture, rural development or nutrition; if so, extent to which activity is specifically designed to increase productivity and income of rural poor; [103A] if for agricultural research, is full account taken of needs of small farmers;

A goal of this project is to increase the productivity and income of the rural poor by increasing or altering energy production at the rural level with new or improved devices that exploit new sources of energy. Increase irrigation, conservation of crops and wood, increased herd size, freeing of time for productive activities, etc., may take place.

(2) [104] for population planning or health; if so, extent to which activity extends low-cost, integrated delivery systems to provide health and family planning services, especially to rural areas and poor;

Although this program has no integrated health delivery system as such, improved health of affected rural poor is expected through devices such as distillers which provide clean water, pumps which allow the organisation of good water, mills which diminish the exhausting work of women, etc. Many of the devices to be tested under this project can serve to replace human energy by utilising alternative sources of energy

(3) [105] for education, public administration, or human resources development; if so, extent to which activity strengthens nonformal education, makes formal education more relevant, especially for rural families and urban poor, or strengthens management capability of institutions enabling the poor to participate in development;

B.1b(3)
The project touches many levels of human resources development. Personnel of the Solar Energy Lab and the Rural Economy Institute Survey Unit will receive training in the U.S. In-country training of enumerators and village-level managers will take place. Close collaboration with the National Direction for Functional Literacy will result in the integration of basic alternate energy technology concepts into Functional Literacy curriculum. Village-level functional literates will play and important part in project studies and the management of devices. Support to the National Engineering School will help creat a solar energy course and provide current state of the art materials.

(4) [106] for technical assistance, energy, research, reconstruction, and selected development problems; if so, extent activity is:

(a) technical cooperation and development, especially with U.S. private and voluntary, or regional and international development, organizations;

B.1b(4)(a)
Peace Corps involvement and the improvement of regional communication in alternate energy research is planned.

(b) to help alleviate energy problem;

B.1b(4)(b)
The main thrust of this project is to help alleviate an energy problem. The funds under this project will be used to test alt nate energy devices which can promote well-being and development at a rural level.

NA- (c) research into, and evaluation of, economic development processes and techniques;

NA- (d) reconstruction after natural or manmade disaster;

NA- (e) for special development problem, and to enable proper utilization of earlier U.S. infrastructure, etc., assistance;

(f) for programs of urban development especially small labor-intensive enterprises, marketing systems, and financial or other institutions to help urban poor participate in economic and social development.

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(5) [107] by grants for coordinated private effort to develop and disseminate intermediate technologies appropriate for developing countries.	NA
c. FAA Sec. 110(a); Sec. 208(e). Is the recipient country willing to contribute funds to the project, and in what manner has or will it provide assurances that it will provide at least 25% of the costs of the program, project, or activity with respect to which the assistance is to be furnished (or has the latter cost-sharing requirement been waived for a "relatively least-developed" country)?	A waiver of the cost-sharing requirement is necessary. The GRM however will fund about _____% of the total project cost. See PP for justification
d. FAA Sec. 110(b). Will grant capital assistance be disbursed for project over more than 3 years? If so, has justification satisfactory to Congress been made, and efforts for other financing?	Yes Yes
e. FAA Sec. 207; Sec. 113. Extent to which assistance reflects appropriate emphasis on; (1) encouraging development of democratic, economic, political, and social institutions; (2) self-help in meeting the country's food needs; (3) improving availability of trained worker-power in the country; (4) programs designed to meet the country's health needs; (5) other important areas of economic, political, and social development, including industry; free labor unions, cooperatives, and Voluntary Agencies; transportation and communication; planning and public administration; urban development, and modernization of existing laws; or (6) integrating women into the recipient country's national economy.	The project will encourage and strengthen institutions at two-levels. At a centralised level support will be given to various schools, labs and rural development institutions. At the village level indigenous or governmental organisation will be encouraged as they serve as managers and maintainers and profit from alternate energy devices. The project emphasises training at all levels from engineers to village managers to survey takers. A project output is increased trained personnel that will enable Mali to plan, implement and evaluate alternate energy source projects. It is anticipated that women will participate in training programs and the management of devices. Most of the devices to be tested respond very well to the needs of women.
f. FAA Sec. 281(b). Describe extent to which program recognizes the particular needs, desires, and capacities of the people of the country; utilizes the country's intellectual resources to encourage institutional development; and supports civic education and training in skills required for effective participation in governmental and political processes essential to self-government.	B1f Appropriate measures are being taken to support academic institutions and to assure coordination of talents, agencies, special interests and resources. To the fullest extent possible the target group of rural people will be involved in the decision-making process.

g. FAA Sec. 201(b)(2)-(4) and -(8); Sec. 201(e); Sec. 211(a)(1)-(3) and -(8). Does the activity give reasonable promise of contributing to the development: of economic resources, or to the increase of productive capacities and self-sustaining economic growth; or of educational or other institutions directed toward social progress? Is it related to and consistent with other development activities, and will it contribute to realizable long-range objectives? And does project paper provide information and conclusion on an activity's economic and technical soundness?	The project contributes to the development of alternate energy sources and devices to exploit these sources. Considering the important role energy plays in development and the increasing price of fossil-fuels, their diminishing quantity and the likelihood that solar energy technologies will become less expensive and more efficient in the future, this project definitely contributes to realisable long range objectives. The PP provides information on the activity's economic and technical soundness.
h. FAA Sec. 201(b)(6); Sec. 211(a)(5), (6). Information and conclusion on possible effects of the assistance on U.S. economy, with special reference to areas of substantial labor surplus, and extent to which U.S. commodities and assistance are furnished in a manner consistent with improving or safeguarding the U.S. balance-of-payments position.	There are no foreseeable adverse effects to U.S. economic interests. In fact the U.S. is one of the leaders in the realm of alternate energy technology and this industry should be stimulated by the procurement of equipment proposed under this project. Assistance will be furnist so as to minimize U.S. balance of payments problem.
Development Assistance Project Criteria (Loans only)	
a. FAA Sec. 201(b)(1). Information and conclusion on availability of financing from other free-world sources, including private sources within U.S.	NA
b. FAA Sec. 201(b)(2); 201(d). Information and conclusion on (1) capacity of the country to repay the loan, including reasonableness of repayment prospects, and (2) reasonableness and legality (under laws of country and U.S.) of lending and relending terms of the loan.	NA
c. FAA Sec. 201(e). If loan is not made pursuant to a multilateral plan, and the amount of the loan exceeds $100,000, has country submitted to AID an application for such funds together with assurances to indicate that funds will be used in an economically and technically sound manner?	NA
d. FAA Sec. 201(f). Does project paper describe how project will promote the country's economic development taking into account the country's human and material resources requirements and relationship between ultimate objectives of the project and overall economic development?	NA

e. FAA Sec. 202(a). Total amount of money under loan which is going directly to private enterprise, is going to intermediate credit institutions or other borrowers for use by private enterprise, is being used to finance imports from private sources, or is otherwise being used to finance procurements from private sources? NA

f. FAA Sec. 620(d). If assistance is for any productive enterprise which will compete in the U.S. with U.S. enterprise, is there an agreement by the recipient country to prevent export to the U.S. of more than 20% of the enterprise's annual production during the life of the loan? NA

Project Criteria Solely for Security Supporting Assistance

FAA Sec. 531. How will this assistance support promote economic or political stability? NA

Additional Criteria for Alliance for Progress

[Note: Alliance for Progress projects should add the following two items to a project checklist.]

a. FAA Sec. 251(b)(1), -(8). Does assistance take into account principles of the Act of Bogota and the Charter of Punta del Este and to what extent will the activity contribute to the economic or political integration of Latin America? NA

b. FAA Sec. 251(b)(8); 251(h). For loans, has there been taken into account the effort made by recipient nation to repatriate capital invested in other countries by their own citizens? Is loan consistent with the findings and recommendations of the Inter-American Committee for the Alliance for Progress (now "CEPCIES," the Permanent Executive Committee of the OAS) in its annual review of national development activities? NA

6C(3) - STANDARD ITEM CHECKLIST

Listed below are statutory items which normally will be covered routinely in those provisions of an assistance agreement dealing with its implementation, or covered in the agreement by exclusion (as where certain uses of funds are permitted, but other uses not).

These items are arranged under the general headings of (A) Procurement, (B) Construction, and (C) Other Restrictions.

A. Procurement

1. FAA Sec. 602. Are there arrangements to permit U.S. small business to participate equitably in the furnishing of goods and services financed?	Yes. Standard procedures will be followed.
2. FAA Sec. 604(a). Will all commodity procurement financed be from the U.S. except as otherwise determined by the President or under delegation from him?	Yes
3. FAA Sec. 604(d). If the cooperating country discriminates against U.S. marine insurance companies, will agreement require that marine insurance be placed in the U.S. on commodities financed?	Yes
4. FAA Sec. 604(e). If offshore procurement of agricultural commodity or product is to be financed, is there provision against such procurement when the domestic price of such commodity is less than parity?	NA
5. FAA Sec. 608(a). Will U.S. Government excess personal property be utilized wherever practicable in lieu of the procurement of new items?	Yes, if available
6. MMA Sec. 901(b). (a) Compliance with requirement that at least 50 per centum of the gross tonnage of commodities (computed separately for dry bulk carriers, dry cargo liners, and tankers) financed shall be transported on privately owned U.S.-flag commercial vessels to the extent that such vessels are available at fair and reasonable rates.	Compliance will be required
7. FAA Sec. 621. If technical assistance is financed, will such assistance be furnished to the fullest extent practicable as goods and professional and other services from private enterprise on a contract basis? If the facilities of other Federal agencies will be utilized,	Grant financed technical assistance will be furnished primarily by private sources contracts.

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are they particularly suitable, not competitive with private enterprise, and made available without undue interference with domestic programs?

8. International Air Transport. Fair Competitive Practices Act, 1974

If air transportation of persons or property is financed on grant basis, will provision be made that U.S.-flag carriers will be utilized to the extent such service is available? — Yes

Construction

1. FAA Sec. 601(d). If a capital (e.g., construction) project, are engineering and professional services of U.S. firms and their affiliates to be used to the maximum extent consistent with the national interest? — Yes

2. FAA Sec. 611(c). If contracts for construction are to be financed, will they be let on a competitive basis to maximum extent practicable? — Yes

3. FAA Sec. 620(k). If for construction of productive enterprise, will aggregate value of assistance to be furnished by the U.S. not exceed $100 million? — Yes

Other Restrictions

1. FAA Sec. 201(d). If development loan, is interest rate at least 2% per annum during grace period and at least 3% per annum thereafter? — NA

2. FAA Sec. 301(d). If fund is established solely by U.S. contributions and administered by an international organization, does Comptroller General have audit rights? — NA

3. FAA Sec. 620(h). Do arrangements preclude promoting or assisting the foreign aid projects or activities of Communist-Bloc countries, contrary to the best interests of the U.S.? — Yes, this will be a part of project agreement and GRM so notified.

4. FAA Sec. 636(i). Is financing not permitted to be used, without waiver, for purchase, long-term lease, or exchange of motor vehicle manufactured outside the U.S. or guaranty of such transaction? — Yes

5. Will arrangements preclude use of financing: Yes

a. FAA Sec. 114. to pay for performance of abortions or to motivate or coerce persons to practice abortions?

b. FAA Sec. 620(g). to compensate owners for expropriated nationalized property?

c. FAA Sec. 660. to finance police training or other law enforcement assistance, except for narcotics programs?

d. FAA Sec. 662. for CIA activities?

e. App. Sec. 103. to pay pensions, etc., for military personnel?

f. App. Sec. 106. to pay U.N. assessments?

g. App. Sec. 107. to carry out provisions of FAA Sections 209(d) and 251(h)? (transfer to multilateral organization for lending).

h. App. Sec. 501. to be used for publicity or propaganda purposes within U.S. not authorized by Congress?

Department of State

TELEGRAM

INFO OCT-01 AF-10 EB-08 OES-07 /071 R

DRAFTED BY AFR/SFWA:LNILLSON:KW
APPROVED BY AA/AFR:WHNORTH
AFR/SFWA:HGRAY (DRAFT)
AFR/SFWA:HFARNHAM (DRAFT)
AFR/SFWA:GWEVANS (DRAFT)
AFR/SFWA/SOP:CULINSKI (DRAFT)
AFR/DR:ODIBBLE (DRAFT)
AFR/DR:JBLUMGART (DRAFT)
AFR/DR:RASSELIN (DRAFT)
SER/ENGR:JMORGAN (DRAFT)
AFR/DP:JGOVAN (DRAFT)
AFR/GC:STISA (INFO)
PC:RTAYLOR (INFO)
DESIRED DISTRIBUTION
ST ACTION AFR CHRON 1 2 6 8 INFO PVC RS PPC FM AA/OS DS/ST ENGR
OA EPA PC 45P

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R 012152Z MAY 78
FM SECSTATE WASHDC
TO AMEMBASSY BAMAKO
INFO AMEMBASSY ABIDJAN

UNCLAS STATE 118768

AIDAC

E.O. 11652:N/A

TAGS:

SUBJECT: SOLAR AID PID (OPERATION ENERGIE NOUVELLE - PROJECT 688-0217)

1. THE SUBJECT PID WAS REVIEWED ON MARCH 28 BY A PROJECT COMMITTEE CONSISTING OF REPRESENTATIVES OF AFR/SFWA, AFR/DR, ENGINEERING, MISSION DIRECTOR LEVIN AND OUTSIDE CONSULTANTS INCLUDING SOME WHO HAD PARTICIPATED IN DEVELOPMENT OF THIS PROJECT. AA/AFR HAS APPROVED THE PID AND THE RECOMMENDATION THAT A PP DESIGN TEAM GO TO MALI IN EARLY MAY. THE COMMITTEE RECOMMENDED THAT THE FOLLOWING ISSUES BE TAKEN INTO CONSIDERATION DURING PROJECT DESIGN.

2. SUGGEST PROJECT BE CALLED OPERATION ENERGIE NOUVELLE TO EMPHASIZE BROAD NATURE OF SOLAR ENERGY. IT SHOULD BE STRESSED THAT THE PROJECT AIMS AT INSTITUTIONAL DEVELOPMENT AS WELL AS SETTING UP OF SPECIFIC PROJECTS. THE PROJECT WILL INCLUDE OPERATING FACILITIES AND NOT JUST CONCENTRATE ON RESEARCH.

3. THE PROJECT MUST BE CONSIDERED IN THE SAHEL DEVELOPMENT PROGRAM CONTEXT. THE REGIONAL ASPECTS OF THE PID MIGHT BE DISCUSSED AT THE FORTHCOMING SDP WORKSHOP. AMONG ISSUES THAT SHOULD BE NOTED ARE AVOIDANCE OF UNNECESSARY DUPLICATION OF PROJECTS IN SAHEL COUNTRIES, POSSIBILITY OF REPLICATION OF SOME OF THESE PROJECTS IN OTHER SAHEL COUNTRIES, RELATIONSHIP OF THE PROJECT TO THE SAHEL ENERGY STUDY BEING CONDUCTED BY THE CLUB DU SAHEL AND THE EXTENT TO WHICH THE CLUB WILL PROMOTE REGIONAL/NATIONAL APPROACHES TO ENERGY MANUFACTURE AND MARKETING. THE QUESTION OF LINKAGES BETWEEN ORGANIZATIONS IN THE SAHEL AND A CONTINUING DIALOGUE BETWEEN NATIONAL INSTITUTIONS SHOULD BE DISCUSSED.

4. FUNDING-SDP FUNDS WILL BE USED. IF PROJECT IS APPROVED FOR FY 78, OYB FOR MALI WILL BE INCREASED ACCORDINGLY.

5. IN PREPARING THE RESEARCH AND DEVELOPMENT BUDGET, THE PP TEAM SHOULD NOTE THE KINDS OF FIELDS INVOLVED, RATHER THAN LINE ITEMS. IT IS IMPORTANT THAT SOLID R&D UNITS BE CHOSEN, WITH COOPERATION OF THE GRM. THE PP TEAM SHOULD CONSIDER WHETHER THE 1/2 HECTARE UNITS MENTIONED IN THE PID ARE TOO SMALL FOR TESTING PURPOSES.

6. THE NEED FOR MANY SEPARATE LOCATIONS FOR PUMPS WAS NOTED. IT IS IMPORTANT TO BE ABLE TO COMPARE THE NEW TECHNOLOGIES TO THOSE CURRENTLY IN USE. CONCERN WAS EXPRESSED OVER SELECTION OF SITES. THE PP TEAM SHOULD CONSIDER WHETHER IT IS WISE TO CONDUCT TESTS OVER SO WIDE AN AREA. THE PRELIMINARY SITE SELECTION SHOULD BE MADE ON THE BASIS OF APPLICATION OF VARIOUS TECHNOLOGIES, RELATIONSHIP TO ONGOING ACTIVITIES IN THE AREA, AND MALIAN PRIORITIES.

7. IT WAS STRESSED THAT CONSTRUCTION OF A SOLAR LABORATORY IS A MAJOR COMPONENT OF THE PROJECT. WHILE THE CONSTRUCTION ELEMENT SHOULD REMAIN, THE PP TEAM SHOULD JUSTIFY IT CAREFULLY, AS LARGE CONSTRUCTION ELEMENTS ARE A MAJOR CONGRESSIONAL CONCERN. IF CONSTRUCTION COSTS ARE TO BE INCLUDED, THEN PRELIMINARY PLANS AND COST ESTIMATES, REVIEWED AND APPROVED BY AN AID ENGINEER, WILL NEED TO BE PREPARED IN ORDER TO MEET 611 CRITERIA OF THE FAA.

8. THE USE OF NON U.S. EQUIPMENT FOR THIS PROJECT WAS DISCUSSED. IF IT IS FELT NECESSARY TO USE FRENCH PVC-POWERED PUMPS, THIS SHOULD BE DISCUSSED IN THE PP. IF FRENCH PUMPS ARE RECOMMENDED, A JUSTIFICATION WAIVER WILL BE NECESSARY. THE ENERGY TECHNOLOGIST OF THE PP TEAM WILL BE RESPONSIBLE FOR KNOWING IF U.S.-MANUFACTURED PVC-POWERED PUMPS ARE AVAILABLE. THE PP SHOULD STRESS THAT AS MANY SIMPLE, LOCALLY MANUFACTUR ITEMS AS POSSIBLE SHOULD BE USED. THE TEAM SHOULD CONSIDER THE POSSIBILITY OF CONTRACTING OUT THE BUILDING OF PROTOTYPES TO SMALL FIRMS IN MALI OR NEIGHBORING STATES AND ALSO THE EXCLUSIVE USE OF MALIAN-MANUFACTURED ITEMS AT ONE OF THE SITES.

9. THE TRAINING AND TECHNICAL ASSISTANCE COMPONENTS OF THIS PROJECT SHOULD RECEIVE GREATER EMPHASIS. THE PP SHOULD INCLUDE DETAILS ON INTERNATIONAL TRAINING AND THE FORMAL LINKS, IF ANY, WITH THE GRADUATE SCHOOL OF ENGINEERING IN MALI.

10. OTHER DONOR PARTICIPATION, PARTICULARLY THAT OF THE FRENCH, WAS DISCUSSED. THERE MAY BE A POSSIBILITY OF THE FAC PICKING UP SOME OF THE COSTS OF THE PROJECT, PARTICULARLY IF FRENCH-MANUFACTURED EQUIPMENT IS USED. THE PP SHOULD TAKE NOTE OF ACTIVITIES FUNDED BY OTHER DONORS T DEVELOP ALTERNATIVE SOURCES OF ENERGY IN MALI. HOWEVER, THE DIFFICULTIES OF JOINT FINANCING SHOULD BE NOTED.

11. PEACE CORPS - THERE IS A PEACE CORPS EFFORT IN THIS AREA. PRIOR TO ARRIVAL OF PP TEAM IN MALI, LEVIN SHOULD DISCUSS WITH PC/MALI A POSSIBLE P.C. ROLE, FOR EXAMPLE, IN PARTICIPATING IN THE VILLAGE-LEVEL SURVEYS CONTEMPLATED IN THE PID. IT WAS SUGGESTED THAT THE P.C. DIRECTOR BE INVITED TO PARTICIPATE IN THE PRE-DESIGN WORKSHOP (SEE BELOW).

12. ENVIRONMENT - THE IEE WAS CONSIDERED GENERALLY SATISFACTORY, BUT SHOULD BE EXPANDED TO TAKE INTO CONSIDERATION (A) BUILDING CONSTRUCTION (NOT EXPECTED TO PRESENT A PROBLEM), (B) WATER IMPOUNDMENT. IT WAS FELT THAT IMPOUNDMENT OF WATER WOULD BE NECESSARY FOR THIS PROJECT AND MUST BE DEALT WITH ASAP, (C) WATER TABLES - THE EFFECT OF PUMPING, ESPECIALLY FOR IRRIGATION ON WATER TABLES, MUST

Department of State TELEGRAM

BE DISCUSSED. REVISED IEE SHOULD BE SUBMITTED ASAP AND AT LATEST BEFORE PP TEAM FINISHES ITS WORK.

13. PROJECT COMMITTEE EMPHASIZED THE IMPORTANCE TO THE PROJECT PURPOSE OF THE TRANSFER OF SMALL RENEWABLE ENERGY SYSTEMS TO THE RURAL VILLAGE SETTING. THIS INVOLVES QUESTIONS OF OWNERSHIP, LOCAL LEVEL MANAGEMENT AND MAINTENANCE CAPABILITY, EQUITY AND SOCIAL ACCEPTABILITY. PP TEAM SHOULD DIRECT PARTICULARLY INTENSIVE EXAMINATION AND ANALYSIS TO THIS CRITICAL PROJECT ASPECT.

14. IT WAS NOTED THAT MORE EMPHASIS SHOULD BE PLACED ON ENERGY CONSERVATION (I.E., THE MANUFACTURE OF MORE EFFICIENT STOVES). THE IMPACT OF THE PROJECT ON VILLAGES, INCLUDING WOMEN SHOULD ALSO BE STUDIED. THIS WILL BE A PRINCIPAL TASK OF THE ANTHROPOLOGIST ON THE PP TEAM. HE SHOULD MAKE MAXIMUM USE OF LOCAL RESOURCES IN THIS STUDY. VANCE

PROJECT DESIGN SUMMARY
LOGICAL FRAMEWORK

Project Title & Number: Mali Renewable Energy 688-0217

Life of Project:
From FY 78 to FY 83
Total U. S. Funding $3.9 million
Date Prepared: 6-15-78

NARRATIVE SUMMARY	OBJECTIVELY VERIFIABLE INDICATORS	MEANS OF VERIFICATION	IMPORTANT ASSUMPTIONS
Program or Sector Goal: The broader objective to which this project contributes: Adapt renewable energy technologies in order to improve material conditions of life in rural Mali.	Measures of Goal Achievement: Substantially increased per-capita production of goods and services at the test sites.	Comparison of base-line survey data with end-of-project results, as provided in plan for Phase IV evaluation.	Assumptions for achieving goal targets: 1) Increased use of renewable energy sources is in Mali's long-term interest. 2) Project will be carried out in approximately the manner described in the PP.
Project Purpose: 1) Identify appropriate sources and applications of renewable energy and develop processes for their introduction in rural communities. 2) Develop capacity of Solar Energy Lab to provide continuing R&D efforts to adapt renewable energy technologies for Malian use.	Conditions that will indicate purpose has been achieved: End of project status. 1) Reduced consumption of petroleum products, firewood or batteries at test sites. 2) Increased discretionary time at the disposal of villagers whose tasks are energized.	1) Comparison of base-line survey data with end-of-project results, as provided in plan for Phase IV evaluation.	Assumptions for achieving purpose: 1) Prices of solar cells fall in accordance with U.S. Department of Energy forecasts. 2) Lab Director and staff undertake vigorous applied R&D effort in priority renewable energy technologies. 3) Malian agencies identified in PP collaborate effectively on Phase II studies and Phase III field tests.
Outputs: 1) Functioning renewable energy devices located at selected village sites; 2) Working System for operation and basic maintenance under local control; 3) Increased in-country survey research capability.	Magnitude of Outputs: 1) Performance of devices at rated capacity; 2) Record of equipment breakdown, repair, and maintenance during test phase; 3) Interim and final reports.	1) Periodic site visits, 2) Inspection of equipment records, 3) Analysis of survey reports, and 4) Continued monitoring by USAID Project Manager	Assumptions for achieving outputs: 1) Water heater, dryer, battery charger, wood-burning stove and biogas generator are technically perfected in Phase II; 2) Rural populace is receptive to new technologies; 3) Village cadre, supported by supervisory teams and Lab, provide on-site services necessary to support continued operation of devices;
Inputs: 1) Capital a) Construction and equipment of new Solar Energy Laboratory; b) Installation of 4 PVC pumps for experimental, demonstration and training purposes; c) Equipment of teams for surveying and testing devices at village sites; d) Fabrication/importation of test devices e) Equipment for ENI, ENSUP, CVL 2) Technical Support 3) Training a) Participants b) Survey teams and village cadre	Implementation Target (Type and Quantity) See budgets	1) Continued monitoring by USAID Project Manager	Assumptions for providing inputs: 1) Committee to evaluate Solar Energy Laboratory performance gives a positive report at end of Phases I and II 2) GOM provides adequate financial and administrative support 3) AID is able to undertake procurement and contracting actions in a timely manner.

APPENDIX Q

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : The Files

DATE: 7 June 1978

FROM : Ronald D. Levin, Director USAID/Mali

SUBJECT: Mali Renewable Energy Project Paper 611-A Certification

I, Ronald D. Levin, Director USAID/Mali, do hereby certify that in my judgement, and upon the recommendation of USAID/Mali Engineer, George Thompson, the requirements of 611-A (1) of the FAA have been fulfilled regarding the substantive technical aspects of the construction of the Solar Energy Laboratory and offices for the Mali Renewable Energy Project. Acceptable preliminary engineering plans and estimates have been completed and a reasonably firm cost estimate of the construction has been made. This 611-A certification is given provided that the construction be done by a qualified construction company or organization according to standard construction procedures, and that final plans, specifications and bid documents are approved by a USAID engineer before disbursement of construction funds.

George Thompson
General Engineering Advisor

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

5010-110

OPTIONAL FORM NO. 10
JULY 1973 EDITION
GSA FPMR (41 CFR) 101-11.6

UNITED STATES GOVERNMENT

Memorandum

TO : The Files

FROM : Ronald D. Levin, Director USAID/Mali

DATE: 7 June 1978

SUBJECT: Mali Renewable Energy Project Paper 611-E Certification

Certification of the Capacity of the Government of the Republic of Mali to Maintain and Utilize Project Inputs

The Mali Renewable Energy Project will touch all seven regions of Mali. Project purposes include (a) assisting the GRM in the conduct of a five year test designed to learn whether new or improved small-scale renewable energy technologies can provide affordable and reliable alternatives to fossil-fuel or traditional energy technologies, (b) assisting the GRM develop the institutional capacity to plan, implement and evaluate alternative energy source projects. Major inputs in terms of institutional support include the construction and equipment of a new Solar Energy Laboratory. Maintenance of the equipment and building will be assured by the Solar Energy Laboratory and the Ministry of Industrial Development and Tourism. The financing of alternate energy devices to be tested at the village level is also a project input. Routine maintenance of these devices will be the responsibility of carefully identified, selected and trained village organizations. Major maintenance activities will be assured by the engineers of the Solar Energy Laboratory. For these activities it appears that adequate financial and human resources exist within the GRM to maintain and utilize project inputs. The maintenance and utilization of inputs by the rural population of Mali has been satisfactory in previous projects financed and assisted by AID.

I, Ronald D. Levin, Director USAID/Mali do hereby certify that in my judgement, based on experience with donor assistance programs in Mali and the level of technology being introduced in this project, Mali will have the financial and human resource capability to effectively maintain and utilize the inputs provided in the Mali Renewable Energy Project.

5010-110

Buy U.S. Savings Bonds Regularly on the Payroll Savings Plan

DEVELOPPEMENT
ET DU TOURISME

1213

N° _____ CAB/MDIT

Bamako le _____

Le Ministre du Développement
Industriel et du Tourisme

à Son Excellence l'Ambassadeur
des Etats-Unis

à BAMAKO

S/C de Monsieur le Ministre des Affaires
Etrangères et de la Coopération
Internationale

-KOULOUBA-

OBJET
Requête de financement du
projet "Développement des
Sources d'Energie
Renouvelables au Mali".

Monsieur l'Ambassadeur,

J'ai l'honneur de vous soumettre la présente requête, dont le coût est de 4.520.000 $ en vue d'obtenir son financement auprès du Gouvernement des Etats-Unis d'Amérique. Comme vous le savez déjà, notre pays a été durant cette dernière décennie, durement frappé par la sécheresse. Pour remédier aux conséquences tragiques de cette calamité dont les manifestations multiples sont durement ressenties en milieu rural, les tâches et actions à entreprendre sont exaltantes et multiples. Pour vaincre la première manifestation de la sécheresse, qui est le manque d'eau, il faut trouver de l'eau et lorsqu'on l'a trouvée il est nécessaire de disposer de l'énergie nécessaire et à bon marché pour son pompage afin de la mettre à la disposition des populations sinistrées et du bétail. Les autres manifestations de ce fléau, déboisement, désertification etc nous ont conduit à concevoir le projet intitulé le "développement des sources renouvelables d'énergie" qui est d'une importance capitale pour notre pays. En effet, au cours de la mise en oeuvre de ce projet dont la durée est de 5 ans, nous nous appliquerons avec l'assitance des techniciens de votre pays, auteur d'un programme bien étoffé, d'étudier tous les aspects de l'utilisation des énergies douces en milieu rural malien.

.../...

Les objectifs que se propose d'atteindre ce projet à savoir, l'étude et l'application de toutes les technologies énergétiques, doivent permettre de recueillir toutes les réactions du monde rural et tous les éléments indispensables à la conception d'une politique énergétique adoptée aux besoins en développement de ce même monde rural, sont restés très longtemps une préoccupation de notre Gouvernement. Il va sans dire, qu'une fois cette politique énergétique conséquente adoptée, il serait plus aisé, avec l'aide de l'US-AID, du Fonds d'Equipement des Nations Unies, des organismes industriels, bancaires etc..., de passer à la production à l'échelle industrielle des résultats obtenus. Ainsi donc nous parviendrons à mettre à la disposition du monde rural, l'énergie bon marché, provenant d'une source perenne, permettant ainsi de résoudre les problèmes épineux de conservations des produits agricoles, des problèmes de chauffage, de production d'eau potable, de pompage d'eau à bon marché pour l'irrigation etc... vous saisissez donc toute l'importance que mon Gouvernement attache à la réalisation de ce projet, c'est pour cela que je vous demande de bien vouloir apporter votre appui à cette requête auprès de votre Gouvernement.

Par ailleurs mon Gouvernement mettra à la disposition de ce projet toutes les ressources humaines, matérielles et financières qui lui seront possibles.

Cette contribution peut se chiffrer comme suit :

- personnel technique national..... 140 millions FM
- personnel administratif..... 30 "
- terrain pour la construction du laboratoire 40 "
- Equipement déjà existant et autres facilités pour le laboratoire..... 350 "
- Eau, téléphone, telex, électricité pendant 5 ans..... 12 "

soit au total 592 (Cinq cent quatre vingt douze)millions de francs maliens.

Veuillez agréer, Monsieur l'Ambassadeur, l'assurance de ma très haute considération./.-

Pour le Ministre du Développement
Industriel et du Tourisme
en mission

Le Ministre du Développement Rural
assurant l'intérim

M'Faguenama KONE

Chevalier de l'Ordre National

République du Mali
Ministère du Développement Industriel et du Tourisme