W.D.R. 78

SOLAR CELL POWER SYSTEM DEMONSTRATION FOR UPPER VOLTA

PROJECT PLAN

for
United States Agency for
International Development

MARCH 27, 1978

Lewis Research Center
Cleveland, Ohio 44135

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

PROJECT PLAN

SOLAR CELL POWER SYSTEM DEMONSTRATION

FOR UPPER VOLTA

Approvals:

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NASA LEWIS RESEARCH CENTER

March 27, 1978

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1.0 INTRODUCTION

1.1 Purpose and Scope

This Plan describes the Upper Volta Solar Cell Power System Demonstration Project to be accomplished by the NASA Lewis Research Center for the U.S. Agency for International Development (AID). This power system project is in support of AID Project No. 931-0234, Studies of Energy Needs in the Food System, the purpose of which is to determine the socio-economic effects of reducing the time required by women of the village of Tangaye, Upper Volta to draw water and grind cereal grain, their primary source of food. The power system project includes the design, fabrication, installation, and monitoring of a solar cell power system for grain milling and water pumping in the village of Tangaye, Upper Volta.

In addition to the project described in this Plan, a socio-economic study, conducted by an anthropologist, is also part of AID Project No. 931-0234. The study is intended to determine village consumption patterns for water and grain milling and time utilization and make recommendations for village management of the new food system facilities.

1.2 Background

In February 1976, a U.S. AID team initiated a project to study the socio-economic effects of introducing electrical power systems to remote villages of developing countries. In April 1976, AID personnel received a mailing from NASA-LeRC soliciting interest in possible joint application experiments

as part of the ERDA/NASA Photovoltaic Tests and Applications (T&A) Project. AID responded with a letter to LeRC dated August 31, 1976, (see Attachment A) which outlined the AID Upper Volta Project and indicated a desire to participate in the ERDA/NASA T&A Project. A preliminary description of a potential solar cell village power application in Upper Volta also was provided.

A number of exploratory discussions and meetings were held subsequently with regard to including this application in the ERDA/NASA T&A Project activities. To this end, an AID/NASA inspection team visited Upper Volta January 15-19, 1977 (see Attachment B for trip report). In February 1977, ERDA directed a programmatic hold on LeRC activities related to the Upper Volta Project.

On July 6, 1977, Dr. Bosken of U.S. AID sent, with ERDA concurrence, a letter to Dr. Bruce Lundin, Director of the NASA Lewis Research Center, requesting NASA technical assistance in implementing photovoltaic system applications in Upper Volta (see Attachment C). On July 14, a preliminary discussion on schedules and resources for the Upper Volta Project was held between LeRC and NASA-Office of Energy Programs personnel and Dr. Bosken and Tom Luche at U.S. AID offices in Rosslyn, Virginia. An official response, agreeing to support the AID request, was made by the NASA Headquarters Office of International Affairs on July 28, 1977.

A Program Development Plan (PDP) was prepared by LeRC and submitted to AID on August 1, 1977. This plan included two demonstrations: (1) a 5 to 6 kW solar cell power system for the village of Tangaye, and (2) a 0.5 kW solar cell system for use as an educational demonstrator at the Interstate University of Rural Engineering. This PDP was not implemented by AID because of budgetary limitations; however, informal discussions have continued since that time and information has been exchanged regarding a scaled-down solar cell system demonstration.

On December 1, 1977, William D. Roseborough, Manager, Energy and Technology Transfer, U.S. AID, requested that LeRC revise the PDP of August 1, 1977, to provide for a solar cell-powered cereal grinding and water pump for the village of Tangaye within a budget limitation of $55K. On December 12, 1977, Mr. Roseborough sent a letter to Mr. Arnold Frutkin, Director for International Affairs, NASA Headquarters, formally requesting LeRC technical assistance for the Upper Volta project (see Attachment D).

LeRC provided for discussion a draft Project Plan, December 16, 1977, within a budget limit of $55K. On January 10, 1978, Mr. Frutkin formally responded to Mr. Roseborough's request for NASA assistance (see Attachment E). He stated that NASA was prepared to provide support, through LeRC, for the Upper Volta project. He noted, however, that the limited AID funding

available for the project may jeopardize its chances for success and that an additional visit to the site would be necessary to gain a better understanding of site-dependent design requirements and operational procedures prior to preparing a formal Project Plan.

A visit was made by W. D. Roseborough, AID, and A. F. Ratajczak and J. E. Martz, NASA-LeRC, to Upper Volta, February 10-26, 1978. The purpose of the trip was to obtain site specific engineering information, complete logistic planning and resolve administrative details relating to the proposed project. A trip report covering the visit is to be found in Attachment F.

Taking into consideration comments received on the December 16 Draft Project Plan and information from the February 1978 visit to Upper Volta, this present Project Plan was prepared.

1.3 Deliverables

The specific item to be delivered is a nominal 1.2 kW (peak) solar cell power system for the village of Tangaye together with grain mill, water pump, and motors providing, respectively, a cereal grinding capacity of approximately 125 kg/day (fine ground) which represents about 5-1/2 hours grinding time and a water pumping capability of 5,000 liters/day.

1.4 Benefits to the U.S. AID Program

Benefits which are expected to accrue as a result of this Project are:

- Demonstration of the feasibility of solar cell power for use in rural areas of developing countries in the Sahel
- Demonstration in a developing country of a small-scale, decentralized, renewable energy source which can potentially reduce dependence on expensive imports of oil and provide an alternative to the nuclear power option
- Development of user acceptance information
- Development of data for cost assessment of solar cell power systems for use in developing countries in other areas of the world
- Provide visibility for AID program.

2.0 TECHNICAL PLAN

2.1 Approach

The NASA-LeRC will manage the design, fabrication, installation, and monitoring of the solar cell power system demonstration defined in this Project Plan. Operating period of the demonstration experiment has been set by AID at one year.

A block diagram of the solar cell power system and its associated loads, as currently envisioned, is shown in Figure 2.1. The location of the solar array, water storage

tank, milling facility, etc., has been determined by mutual agreement with the AID Mission, Upper Volta, and the Tangaye village officials during the recent site visit. A preliminary design of the system has been prepared for cost estimation purposes and draws upon the best currently available information.

2.2 Activities

The activities required to accomplish the Plan objectives are:

(1) System Design

(2) Component Procurement, Fabrication and Delivery

(3) Checkout Tests

(4) Shipping

(5) Site Preparation

(6) System Installation and Checkout

(7) System Operation Monitoring

(8) Data and Reporting

Overall project management will also be provided to assure that these activities are successfully completed within the established schedule and resources. Close liaison will be maintained with the AID Program Manager and monthly progress reports will be provided.

2.2.1 System Design

The size of the solar cell power system is primarily determined by the project resource limit of $55K.

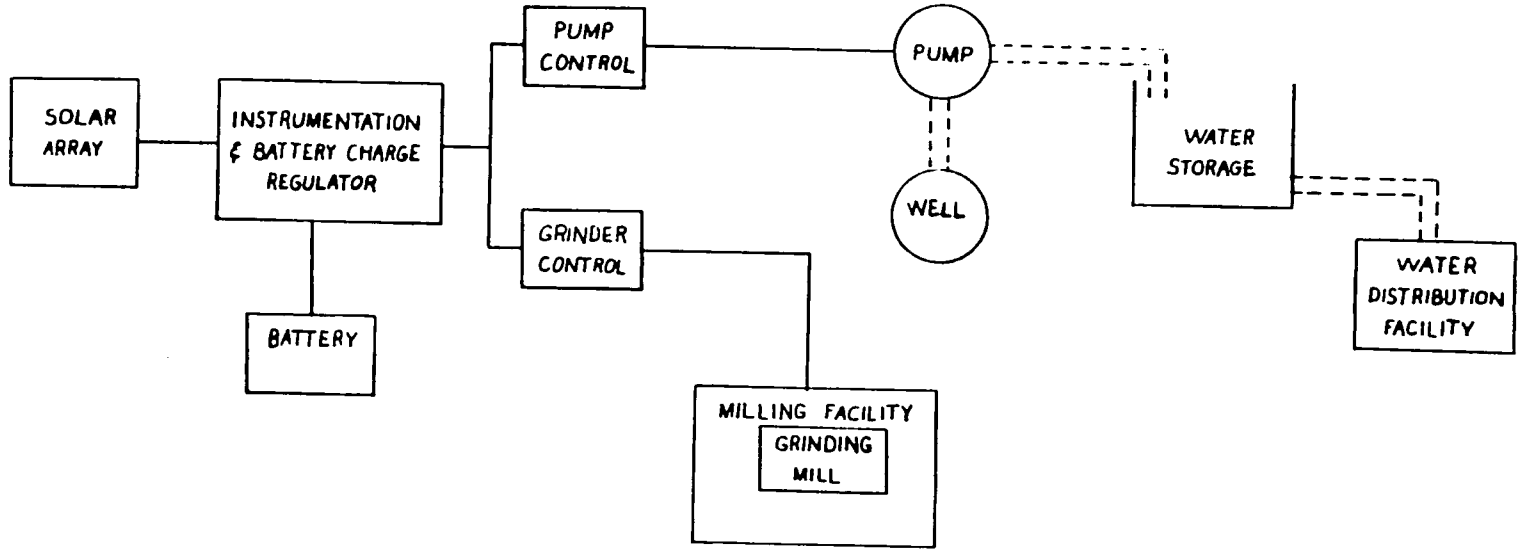


FIGURE 2.1 - BLOCK DIAGRAM

SOLAR POWERED WATER PUMPING AND CEREAL GRINDING FACILITY

TANGAYE, UPPER VOLTA

SYM.	NO.	DESCRIPTION	APP./DATE
		REVISIONS	

NASA LEWIS RESEARCH CENTER CLEVELAND, OHIO 44135

SCALE

REFERENCE

CB

OFFICIAL DATE 12-9-77

Power system size, then, determines the amount of energy available for water pumping and grain milling at the site. A computer program developed at LeRC is used to make a trade-off between array and energy storage size, taking into account load requirements for the pump and grinder, solar insolation and cloud cover data, etc. Following completion of the design, LeRC will conduct a system design review for AID.

2.2.2 Component Procurement, Fabrication and Delivery

Under this activity, component specifications will be developed and all hardware will be procured and/or fabricated. A number of long lead-time items such as storage batteries and solar cell modules will be ordered as early as possible in order to meet the key milestones of the schedule. At present, delivery time for the batteries is a pacing item in setting the schedule. We have been advised by the vendor that because of the energy situation due to the national coal strike his plant is operating part time and therefore he will not promise less than 18-week delivery after receipt of order.

Because of fund limitation no battery or solar cell module spares will be ordered at this time.

2.2.3 Checkout Tests

All components except the solar cell array and batteries will be tested individually and as part of an integrated subsystem prior to shipment to Upper Volta. The solar cell modules mounted and wired into panels will be checked for performance using a pulse-type solar simulator. The instrumentation

and data acquisition devices will also be included in these tests.

2.2.4 Shipping

Because of the high cost of air shipping, all system components will be shipped by surface transportation. The estimated overall shipping time is about 10 weeks from U.S. to Tangaye, Upper Volta.

If possible, all items will be consolidated into a single containerized package. The LeRC will ensure delivery to the U.S. port of export and on-loading onto a ship. AID will provide transportation monitoring from port-of-entry (Abidjon, Ivory Coast) to Ouagadougou and from the rail head in Ouagadougou to the AID compound or warehouse and will provide storage in Ouagadougou. AID will pay all duties and provide appropriate customs export (U.S.) and import (U.V.) documents. Shipment from Ouagadougou to Tangaye will be by truck monitored by LeRC.

2.2.5 Site Preparation

The area where the array, cereal grinder, and water storage are to be located will be prepared and a shelter for the grinder will be erected. Village labor, local building materials and land are to be provided as a contribution in kind by the government of Upper Volta to this project. Technical

guidance of these activities will be provided by LeRC. Supervision of the site preparation will be provided by AID (Allen Clark).

2.2.6 System Installation and Checkout

Construction management will be provided by LeRC for the installation of the solar cell power system and its associated equipment. LeRC personnel will direct and assist in the assembly, installation and checkout of all hardware. AID will provide, as needed, office space and equipment, in-country transportation, interpreters and secretarial services, medical facilities, and official vehicles. The villagers will provide, as needed, labor required for system installation.

2.2.7 System Operation

Following final checkout, LeRC personnel will provide orientation and instructions on system operation and maintenance for the villagers. AID will arrange for an individual to be instructed and trained by LeRC personnel in data acquisition, maintenance, troubleshooting, and minor repairs. The designated individual should be available during the installation and check-out period. This individual would be expected to send, periodically, magnetic data tapes and other information regarding system operation to LeRC for analysis.

The period of operation for this system demonstration experiment has been set by AID at one year. It is recommended that follow-up visits by LeRC personnel be conducted at six-month intervals during this period to monitor performance and to deter-

mine acceptability of the system. Since the present budget does not provide for such visits nor for data analysis and reporting, additional funding in FY'79 would be required.

Following the operation period of the demonstration, AID will make a decision regarding final disposition of the system.

2.2.8 Data and Reporting

This effort includes selection of a data system, data formating, reduction, analysis, and evaluation. The data system will be a stand-alone, automatic unit, provided on loan by the LeRC. Data will be recorded on cassette tape which would be sent periodically to LeRC for reduction and analysis.

Monthly reports will be provided to AID from project initiation up to the start of system operation. During the operating period, status reports will be provided every six months following a site visit. A final report covering performance and cost analyses and evaluation will be provided following the end of the demonstration-operation period.

2.3 Schedule

The schedule for the subject demonstration up to the operational phase is shown in Figure 2.2. At present there are two sequential schedule pacing items: battery delivery (see section 2.2.2) and shipping (see section 2.2.4). These, in effect, determine the overall time from Plan approval to start of system operation, i.e., 8-1/2 months.

2.4 Resources

2.4.1 Fiscal Year 1978

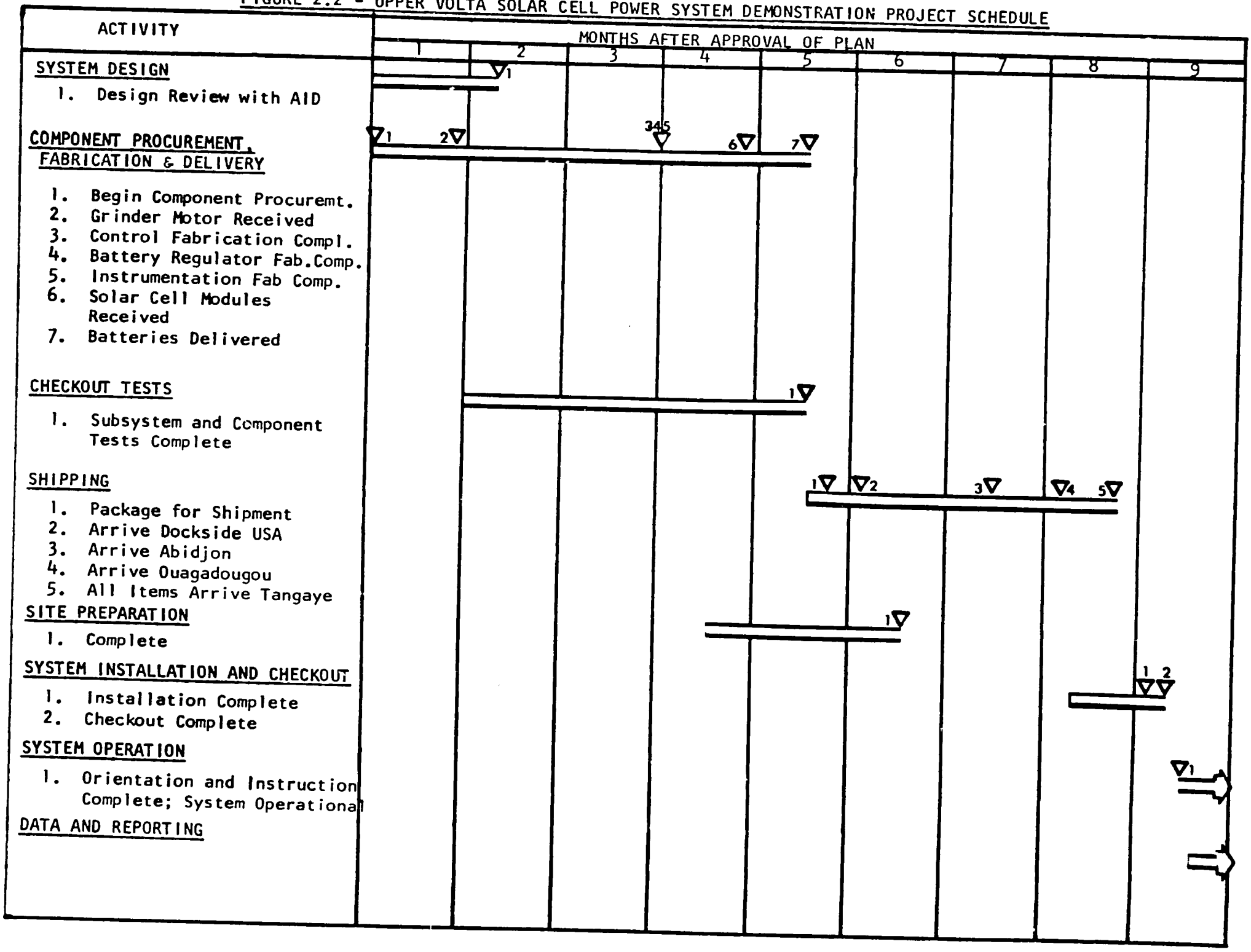
A breakdown of the estimated costs associated with bringing the demonstration to the operational stage are presented in Table 2.1 Included are hardware, shipping, travel, documentation and installation. These estimates are based on recent experience with similar projects implemented by LeRC and on recent telephonic quotes from vendors. The contingency should cover the uncertainty in the cost estimates and other unforeseen expenses.

LeRC manpower for project management and technical support will be provided at no charge by NASA as requested by AID (see Attachment D). It is estimated that 1-1/2 man-years will be required over the eight- to nine-month period of this work.

2.4.2 Fiscal Year 1979

The resources required to cover the one-year operational phase of the demonstration are estimated to be a total of $24K. Of the total, $15.6 is for LeRC manpower (0.4 man-year at $39K/man-year) for system monitoring, data analysis, technical and cost evaluation, and report preparation. The remaining $8.4K is for two trips to the site for operational monitoring and to cover any major repairs or alterations required.

FIGURE 2.2 - UPPER VOLTA SOLAR CELL POWER SYSTEM DEMONSTRATION PROJECT SCHEDULE



2.4.3 Funding Augmentation

AID-OST and AID-UV have determined that the original funds allocated for this project on June 24, 1976, are not sufficient to cover: (1) the equipment power demand (especially for milling where 2-1/2 hours per day additional operating time is desired, over the present 5-1/2 hours per day), (2) cost of NASA monitoring and reporting during the operating period, (3) spare parts, and (4) subsequent effects of inflation. To remedy this an Accelerated Impact Program (AIP) funding request has been made by AID-UV for $55K to be added to money allocated already. Of this new money, NASA would propose that $24K would cover the work described in section 2.4.2, above, and that the remainder be used for add-on to the power system, spares, and shipping.

At such time as these additional funds are available, LeRC will prepare a supplement to this Plan to cover the augmented effort.

3.0 PROJECT ORGANIZATION

The organization structure of LeRC is shown in Figure 3.1. The overall responsibility for the Upper Volta Solar Cell Power System Demonstration Project is assigned to the Terrestrial Photovoltaic Project Office (TPPO) which is within the Solar and Electrochemistry Division of the Directorate of Energy Programs (see Figure 3.2).

Within the TPPO, Mr. William J. Bifano - designated the Village Power Manager - has been assigned to manage the work described in this Plan.

TABLE 2.1 - COST BREAKDOWN FOR UPPER VOLTA SOLAR CELL POWER SYSTEM DEMONSTRATION PROJECT, FY'78

Solar Cell Power System, 1.2 kW peak Module, Structure, Wiring, Batteries Controls, Instruments, Installation, etc.		$37.2K
Loads		2.2K
Water Pump & Motor	$1.5K	
Grain Grinder & Motor	0.7K	
Shipping		4.0K
Travel (Assoc. with Technical Management)		8.1K
Engineering Drawings and Documentation		1.0K
Contingency		2.5K
	TOTAL:	$55K

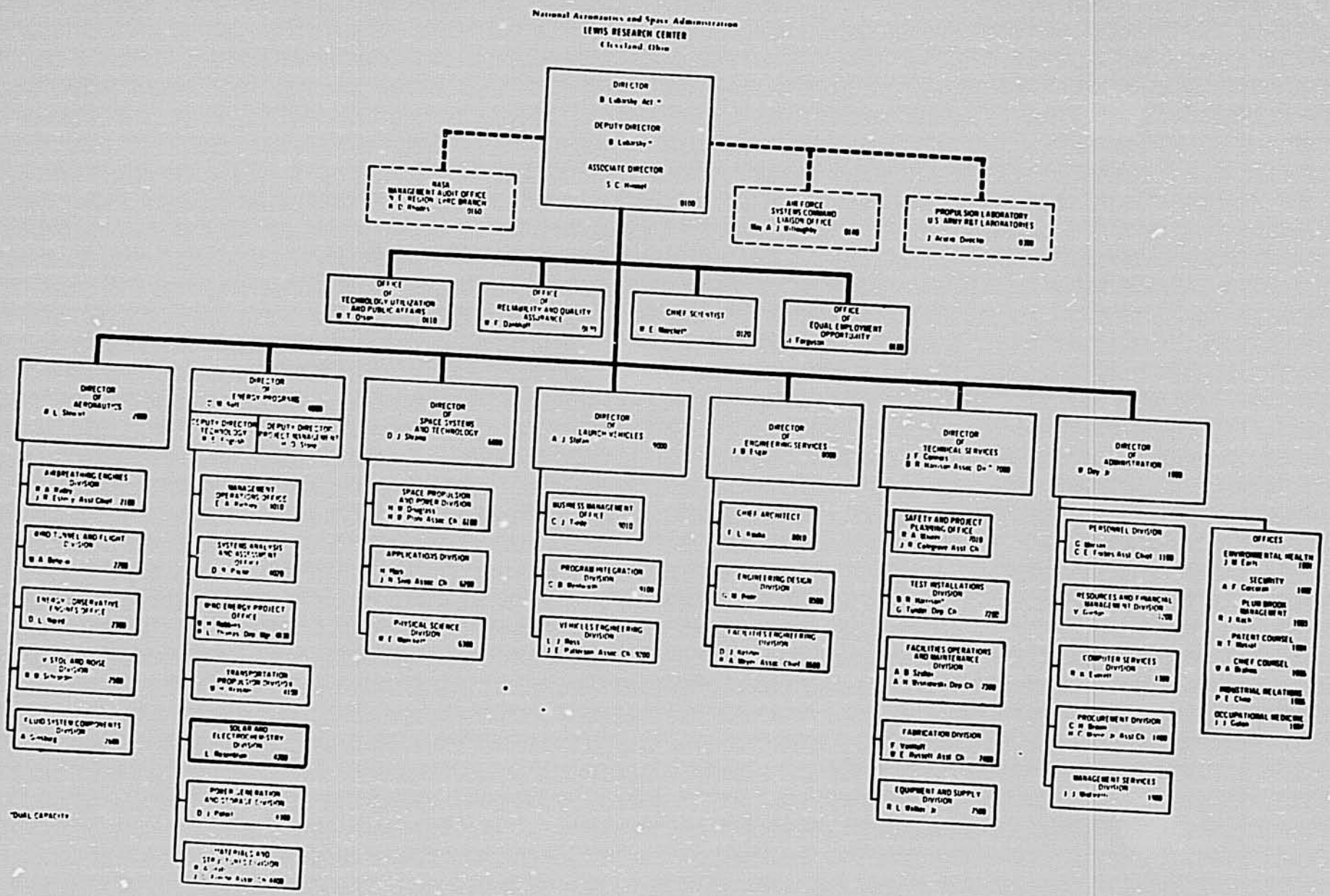
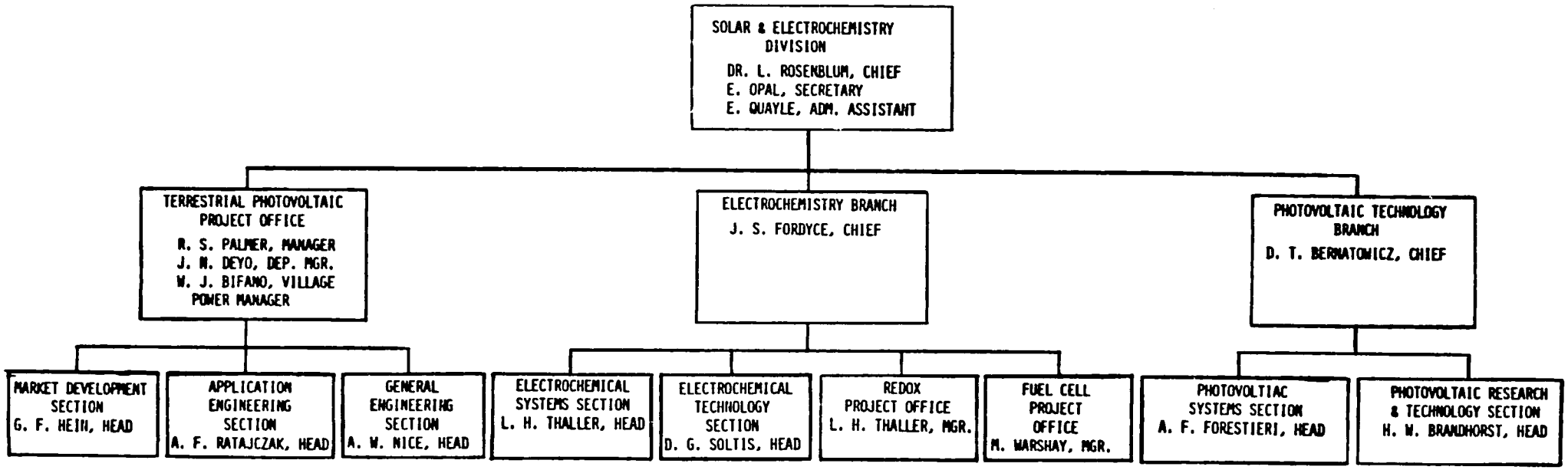


FIGURE 3.1 - NASA LeRC ORGANIZATIONAL STRUCTURE



3.2 - SOLAR AND ELECTROCHEMISTRY DIVISION ORGANIZATION CHART

4.0 ATTACHMENTS

ATTACHMENT A

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

August 31, 1976

Mr. James N. Deyo
Manager, Photovoltaic Test
and Demonstration Project
NASA/Lewis
Cleveland, Ohio 44135

Dear Mr. Deyo:

The Agency for International Development would welcome an opportunity to participate in the ERDA/NASA Photovoltaic Test and Demonstration Project. We are currently preparing a project in Upper Volta which would be, in our view, an ideal medium-size application of solar cells in a developing country. We have received approval for this project and have obligated the money to it.

The technical guts of this project is the provision of a stable, assured energy supply to two villages in Upper Volta to power village water pumps and cereal grinders. Our rather quick estimate of the energy needed is 5 Kw. hr. per day for each installation. The justification for this figure is given below.

Storage will be achieved principally through the products produced: water in a tank, ground grain. It will not be necessary to store energy from day to day although the power for "start-up" and the daily load cycle might necessitate some temporary energy storage.

Because of the remoteness of the area and its high solar insolation, solar cell arrays are a priority choice for the power source.

We would envision that each of the two villages would be supplied with an array of 1000 peak watts. This figure is based upon 10 hours of sunshine per day and the assumption that the average wattage is one-half the peak wattage. The resultant 5 Kw. hr. requirement of each village is derived as follows:

<u>Water:</u> 1000 people/village
4-25 liters/person/day
10 meter water table
0.1-0.7 Kw. hr. of work done

~ 0.33 efficiency (electrical output to water raised)
1-2 Kw. hr. of electrical output needed

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<u>Cereal</u>: 1000 people/village
.5-1 lb/person/day
<u>grinder</u> - 120-160 lbs/hr.
4-6 hrs./day
750 watts
3-4 Kw. hr. of electrical output needed

Technical monitoring could be accomplished through the services of the Inter-State University of Rural Engineering. Based upon prior discussions, they would most likely be very interested in participating in this project. Ownership of the arrays and the disposition of them after the conclusion of the demonstration would pose no problem. For example an appropriate solution could be to place the equipment under the Regional Development Organization of Upper Volta responsible for the activities in the region where AID is focusing its efforts. During the course of the experiment, AID would maintain responsibility for the equipment.

The ultimate goal of the project is to determine the socio-economic effects of reducing time spent in laborious tasks. This information will be useful in preparing future AID projects in the region. To achieve this goal, we need a trouble-free, dependable power source; the cost of that power is of secondary importance.

We realize that this description of the project is indeed preliminary and that important technical details are missing. We can provide required further information and/or are willing to work closely with your staff in developing all the data needed for project implementation. We are enthusiastic and "ready-to-go" on this activity and await only a final decision on its suitability for inclusion in the ERDA demonstration program.

Sincerely,

Jerome J. Bosker
Office of Science and Technology

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ATTACHMENT B

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
CLEVELAND, OHIO 44135

REPLY TO ATTN OF: 4221

February 24, 1977

MEMORANDUM FOR RECORD

FROM: Terrestrial Photovoltaic Project Office (4221)

SUBJECT: Trip Report for January 15-29, 1977 to Dakar, Senegal, Ouagadagou, Upper Volta, Niamey, Niger (Africa) and Paris, France

This report is intended to be a fairly brief summary. If greater detail is needed, contact Phillip L. Stone or Anthony F. Ratajczak. The trip was made with Jerome Bosken, AID, Washington.

Arrived Dakar, Senegal on Sunday, January 16. On Monday we visited Jim Prokopius' AID Mission Office to describe AID/ERDA project in Upper Volta. We then met with Souleymane Ndiaye, a government official very knowledgeable about energy affairs in Senegal. An interpreter was needed--French was spoken. Their main application for solar energy would be water pumping; also, refrigeration for food storage is greatly needed. In Dakar electricity is ∿$0.30/kWH; in the countryside it is ∿$0.75/kWH and rising. Mr. Ndiaye showed us a study, prepared by the Brace Institute of McGill University for UNEP, of the energy needs of Senegal. Bosken plans to review the study with the thought of getting more AID people involved in the energy affairs of Senegal (early planning stages) in order to have a firm basis for setting a project(s) there.

Our next meeting was with Professor D. Fall. Le Directeur of the Institut de Physique Météorlogique, segment of the University of Dakar. We observed some Sofretes thermal pump set ups and discussed solar energy in general. We discussed the possibility of installing an insolometer at the Institute. They are presently taking global insolation data. (H. Brandhorst has been appraised of the insolometer possibility at the IMP.)

We also met with Dr. Kooi, a new visiting professor at the University of Dakar. We were told that some P/V panels at the University of Dakar had degraded badly--one was French, the other USA but were unable to arrange a visit to see them personally. Dr. Kooi agreed to check into it, take pictures, etc., and send us a brief report.

On Tuesday, we arrived in Ouagadougou, Upper Volta. We met with Alan Bell of AID and discussed various candidate villages for water pumping and cereal grinding. One prime candidate was Tangaye ∿195 km east of Ouagadougou on the main road. Another was Ougarou, also on the main road but ∿295 km from Ouagadagou. We then made plans to drive to Fada n'Gourma (∿235 km from Ouagadougou) and use it as a base of operation. After making plans, we met with the U.S. Ambassador, Mr. Graham. He is an avowed solar energy supporter. In addition to our project, he is pushing hard for solar cookers and a refrigerated warehouse for foodstuffs and seed potatoes. Ouagadougou would very much like to save some potatoes for planting instead of every year importing expensive seed potatoes. Ouagadougou requires vast quantities of scarce and expensive wood for cooking and beer (Dolo) making. The latter is a major cash enterprise--but lots of simmering--lots of wood. Numbers quoted were ∿$14/mo/household for wood for all uses. Mr. Graham was very concerned, in general, that if the USA does not move fast in the Sahel, the French will get the whole market. He thought that a professional foreign service officer from the State Department should be detailed to ERDA to get things really rolling (Bosken will inquire).

On Wednesday we drove to Fada n'Gourma, arriving in mid-afternoon. There we met with Tom Luche an AID employee who spends considerable time in the villages and who was part of the village selection team. We subsequently met with a top regional government man, the head of the Eastern ORD (Office of Regional Development), and men from the Upper Volta ORD Engineering Offices. The candidate villages are in this Eastern Region. We planned our village trips for the following day.

On Thursday we picked up a man from Engineering and drove to Tangaye. It is a village of over 2000 people and is divided into several cartiers (pods, modules, sections). We judged that it had a very good appearance overall. We met the Chief, a very key person for the project, and his men's council. They seemed quite interested in spite of language difficulties (we spoke English to Alan Bell; he spoke French to an interpreter who spoke Mōre to the Chief, et al). The tribe is Mossi. My demonstration of the water wheel*went very nicely. We then visited the main well and took lots of data. The daily usage of water is ∿50,000 liters and for cereal ∿0.5 kg/person/day. We then witnessed a hand cereal grinding operation. We took lots of pictures of all activities. Once assembled again, the Chief presented us with two live chickens, and some village peanuts for his son who is a diplomat in Washington, D.C.

In the afternoon we drove to Ougarou. That village is somewhat smaller than Tangaye, ∿220 people. The Chief and several others, including the women's council met with us. Again translation was a chore, but again all were very interested. The water wheel went nicely again. We then visited the well. We judged it to be too close to the road and in too congested a location. The water and cereal data for this village are: ∿3700 liter/day of water and ∿2 kg/person/day of cereal. We then drove back to Fada, ate dinner and returned to Ouagadougou at about midnight.

On Friday we discussed the findings from Thursday's visits and chose Tangaye as the most appropriate site. It may not be possible to provide power for all the water pumping and cereal grinding needs but most would be covered. We also discussed a refrigerator installation (either for human medicines or animal vaccines) and asked Alan Clarke, a Peace Corp worker who will probably come to work for AID, to get some basic site data and pictures to enable us to select a location and design the system. In addition to the refrigerator installation, we are hopeful that Alan Clarke will oversee the installation of the water pump, cereal grinder, and solar cell array and follow its use somewhat.

The final meeting of the day was with Dr. Viredique, the Director of the Interstate School of Rural Engineering, and Mr. Lamadieu, a solar energy person. They expressed interest in getting an isolometer for the school. We also

*LeRC portable solar photovoltaic powered miniature water pumping demonstration model.

discussed installing a small demonstration water pump at the school. The insolometer-pump situation he felt would need some sort of protocol agreement; we'll have to look into this fairly quickly. Also, he thought that an agreement between AID and the school could be worked out fairly simply so that they could monitor the village pump and grinder installation.

On Saturday morning we met with Ambassador Graham briefly. We told him of our findings and tentative decisions. He was most interested and supportive. He pushed hard once again for a solar cooker. Bosken mentioned that AID would have such a project in Haiti and, hopefully, the technology could be transferred to Upper Volta soon.

On Monday morning we revisited the Interstate School for a tour of the facilities. They also had a Sofretes pump and an experimental trickle irrigation system. Later in the day we secured a lot of insolation data from NSECNA, an organization similar to our NOAA and FAA. In the evening we flew to Niamey, Niger.

On Tuesday morning we met with an AID contact, Roy Harrell. A meeting at the Solar Energy Institute had been planned, but the contact had been called away. We met instead with the Director of the AID Mission, Al Barron. He expressed great interest in our plans. He noted that solar cooking was also a great need of Niger. He informed us that there were some 2,000 villages in Niger, and it was the government's plan to provide all of them with wells and water pumping.

On Wednesday morning we met with Dr. Wright at the Solar Energy Institute. A tour followed; they were by far the best equipped solar installation we had seen. They had a Sofretes pump, solar stills (aluminum frames, stainless steel tubes), and a complete insolation station (direct, diffuse, and global insolation). A company that they support in Niamey is making ∿5 solar water heaters per day. In the afternoon we flew to Paris.

On Thursday morning we met with Mr. DuFour of the Sofretes Company at the U.S. Embassy in Paris. We described the ERDA solar energy program and, in particular, the photovoltaics program and LeRC's role in the P/V program. We also described the AID project in Upper Volta concentrating on the socio-economic aspects of the project. Mr. DuFour described Sofretes as basically a privately-owned company but tied in closely with the French AEC who appears to be the energy focal point in France as ERDA is in the USA. They also have a close association with Renault especially in Africa. Renault, in effect, markets and services their products. They are planning ∿13 pumps along a trail in northern Upper Volta. They have installed several pumps in Mexico--the cost is ∿$40,000 per unit for a 1 kW pump, but they believe the price will go down as pump parts start being made in the various countries where the pumps are installed. At the present time much of the financing of the pumps is by donors although Arabian countries and Mexico are beginning to purchase for themselves. They are working toward photovoltaic systems, also. R.T.C. of France would provide the solar cells at ∿$20.00 a peak watt. Sofretes does all the system design of P/V systems. They have had some contact with American cell manufacturers. They would use pumps from Rateau or Guinard with DC motors. They are considering a Mengin pump--fairly new, positive displacement. They are very concerned about P/V prices and about heat and sand in arid areas. They will apparently not go very far with solar cells unless the price drops noticeably. They also believe 1-5 kW installations could be good for solar cells--but for 5 kW and above, some kind of solar thermal is better. We'll ask all U.S. solar cell manufacturers to send them data.

We also met with Pat Murphy, a NASA representative at the Embassy and with Ted Beresovski, an ERDA representative, also at the Embassy. We also met with Joan Plaisted and Nicole Cointet of the Embassy who will get us data on French pumps and grinders (prices and spec's). It might make a lot of sense to use "local" products in Africa (parts availability, etc.)

Phillip L. Stone

Anthony F. Ratajczak

cc: AID/J. J. Bosken
ERDA Headquarters
Attn: Dr. H. L. Macomber
Dr. N. L. Brown
NASA Headquarters
Attn: NT/Mr. H. K. Strass
0100/B. Lubarsky
4000/G. M. Ault
4000/H. O. Slone
4200/L. Rosenblum
4220/PVPO File
4220/R. S. Palmer
4220/J. N. Deyo
4221/G. F. Hein
4221/P. L. Stone
4222/A. F. Ratajczak

DEPARTMENT OF STATE
AGENCY FOR INTERNATIONAL DEVELOPMENT
WASHINGTON, D.C. 20523

July 6, 1977

Dr. Bruce London
Director
National Aeronautics and Space Administration
Lewis Research Center
Cleveland, Ohio 44135

Dear Dr. London:

For approximately one year, our office in the Agency for International Development has been engaged in discussions and preliminary planning with personnel from ERDA and Lewis Research Center concerning the Photovoltaic Test and Demonstration Project. We wished to participate with a test of the technology in a village setting in Upper Volta, a developing country south of the Sahara Desert in Africa.

After thorough consideration, ERDA's Solar Energy Division decided not to engage in international demonstrations of this type due to limited ERDA staff available to manage the activities and to the lack of specific authorization for such efforts. AID however remains very interested in testing photovoltaics in developing countries and we are willing to support fully the expenses of such tests. We have discussed our options with the personnel of ERDA's Photovoltaic Program and have received their clearance to contact directly their prime contractors.

In order to minimize the time spent in further discussion, we are seeking technical assistance initially only from LeRC. If you cannot provide the needed assistance, we will then approach the other two ERDA contractors. We had three principal reasons for reaching this decision: A two-man technical team from LeRC has already visited Upper Volta to prepare a preliminary design of the proposed test; LeRC has prior experience in designing photovoltaic demonstrations for use in remote areas; and AID has existing mechanisms to acquire needed technical skills in a timely fashion from other Federal agencies.

The specific technical assistance that we desire from LeRC is the provision of two photovoltaic systems. This would entail the design of the system, purchase of the photovoltaic arrays and ancillary hardware, system check-out in Cleveland, delivery to and installation in Upper Volta.

rec'd 7/11/77

We anticipate that a total of 1-2 man-years of LeRC personnel support would be needed, to begin in FY 1977 and carry through FY 1978. The two systems would be a water pump (about 500 watts) and a village size unit (5-6 kilowatts) to power a cereal grinder and a water pump. These power figures are estimates only since detailed design work and testing of devices will be needed before final figures can be given.

If you decide that Lewis Research Center can provide the needed services, we will initiate the process of arranging for the funding and specifying the details of the project in an Interagency Participating Services Agreement between AID and LeRC.

We would appreciate your consideration in informing us of the results of your decision as soon as possible so that we might approach the other ERDA contractors if necessary.

Sincerely,

Jerome J. Bosker
Office of Science & Technology

cc: Mr. Lou Rosenblum, LeRC
Dr. Hal Macumber, ERDA/Solar Energy
Dr. Norman Brown, ERDA/International

ATTACHMENT D

12 December 1977

Mr. Arnold Frutkin
Director for International Affairs
NASA Headquarters (Code I)
Washington, D.C. 20546

Dear Mr. Frutkin:

The Agency for International Development (A.I.D.), in order to implement its responsibility to provide energy assistance to developing countries and to demonstrate renewable energy technology for use in the development process, is planning coordinated demonstrations of photovoltaic energy technology. To achieve these objectives we need technical support in photovoltaics in order to proceed with a demonstration project in a village in Upper Volta.

Recognizing the technical expertise in this area at the NASA Lewis Research Center and their proven ability to design, construct and test photovoltaic devices and systems which have been utilized reliably in remote locations, we would find technical support by the NASA/Lewis staff of great assistance for our current activities.

We have held several discussions with representatives of NASA/Lewis, NASA/Office of Energy Programs, and your office concerning this activity. Although we are not in a position to pay for these services at this time, estimated at a total of two (2) man-years, we anticipate that future services in this field would be reimbursable by A.I.D. The magnitude of our future requirements cannot be specific at this time; however, we anticipate extensive and continuing A.I.D. interest in the photovoltaic area and would look to NASA for technical assistance in our program.

A.I.D. is prepared to work out, in concert with a NASA designated representative, a draft of a Participating Agency Service Agreement (PASA) covering the roles and responsibilities of each agency in implementing the above described activities.

Sincerely yours,

William D. Roseborough
Manager, Energy & Technology Transfer
Office of Science & Technology

cc: Dr. L. Rosenblum (NASA/Lewis)
Mr. H. Kurt Strass (NASA/W)

Mr. H. A. Arnold (OST)
Dr. J. J. Bosken (OST)

ATTACHMENT E

National Aeronautics and
Space Administration

Washington, D.C.
20546

Reply to Attn of LI-15

JAN 10 1978

Mr. William D. Roseborough
Manager, Energy & Technology Transfer
Office of Science & Technology
Agency for International Development
Department of State
Washington, DC 20523

Dear Mr. Roseborough:

This is in response to your letter of December 12, 1977, requesting NASA technical support in implementing a demonstration renewable energy technology project in Upper Volta using photovoltaic devices.

We are prepared to provide the NASA support requested from the NASA Lewis Research Center (LeRC) for a first demonstration with all costs other than personnel to be the responsibility of AID. As indicated in your letter, we would expect that in future support arrangements of this type, AID will fund all costs on a reimbursable basis.

As you know from the discussion in your office on December 20 with Dr. Rosenblum of LeRC and Mr. Strass of this office, we are concerned that the limited AID funding available for the proposed project may jeopardize its chances for success. We also feel that an additional visit to the proposed site is necessary to gain a better understanding of site-dependent design requirements and operational procedures. These requirements and procedures must be firmly established prior to preparing a formal Project Plan.

To complete the arrangements for this project, we are designating the following points of contact: Ms. Lisa Robock (telephone 755-3883) of the International Affairs Division for international policy and procedural matters and Mr. Kurt Strass (telephone 755-8557) of the Solar Energy Division for program considerations and project planning.

These representatives will work with your office to develop a Participating Agency Service Agreement which will define the roles and responsibilities of the two Agencies, leading to a mutually approved Project Plan.

Sincerely,

Arnold W. Frutkin
Director of International Affairs

cc:
R-14/Mr. Ginter
LeRC/Mr. Rosenblum

ATTACHMENT F

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
LEWIS RESEARCH CENTER
CLEVELAND, OHIO 44135

REPLY TO ATTN OF 4222

March 21, 1978

MEMORANDUM

TO: 4200/Chief, Solar and Electrochemistry Division

FROM: 4222/Head, Application Engineering Section

SUBJECT: Trip Report; Centre National de Recherches Agronomiques, Senegal, and Ouagadougou and Tangaye, Upper Volta, February 8-26, 1978, Re: USAID/NASA LeRC Photovoltaic-Powered Village Cereal Grinding and Water Pumping Project

The objectives of this trip were (1) to visit two experimental, post-harvest technology systems operating in Senegal to observe and discuss the various aspects of implementing such technology in rural west Africa, and (2) to visit Ouagadougou and Tangaye, Upper Volta to obtain site specific engineering information, complete logistics planning and to resolve administrative details of the proposed subject project.

We, A. F. Ratajczak and J. E. Martz - NASA, LeRC, and W. D. Roseborough - OST/USAID, arrived in Dakar, Senegal at 2355 hours, February 10, 1978, 36 hours later than originally scheduled, sans baggage, and after a greatly encumbered trip from Cleveland and Washington via New York, Paris and Rome.

CNRA, Bambey Senegal, February 10-14, 1978

The Centre National de Recherches Agronomique (CNRA) is, as the name implies, a Senegalese government organization engaged in a wide range of agricultural research projects aimed at improving agricultural output and utilization. The project of particular interest to us, Post-Harvest Technology, is being sponsored by the International Development Research Centre (IDRC), a Canadian-based and Canadian-funded organization whose board of directors is composed of 11 Canadians and 10 international representatives including

one from the U.S. The Project is being administered for the IDRC by Mr. Robert Forest, Assistant Director Agriculture, Food and Nutrition Science Division, University of Alberta, Edmonton, Canada. The Director of the IDRC in Senegal is Dr. Gordon Yaciuk who left for Ottawa the day preceding our arrival. The IDRC Research Advisor at CNRA, Mr. Richard Lalonde, has been associated with the project for approximately one year. The objectives of the present effort in this project are:

- to establish suitable post-harvest systems in two Senegal villages
- to study in detail the components of the system, in particular, how they relate to each other
- to study in detail the economic and technical efficiency of the systems as operated in the villages
- to train Senegalese research staff and "vulgarisateurs" to continue post-harvest systems research and application in Senegal and elsewhere in the region.

Two villages have been selected in which to implement these studies. Ndiamsil, a village of about 50 families, is located about a 1/2-hour drive NNE of Bambey. The other, Sonkorong, is located about a 3-hour drive south of Bambey and is SE of Kaolack near the northern Gambia border. We visited Ndiamsil on Friday, February 10, and Sonkorong on Monday, February 13.

The system at Ndiamsil has been in operation since October 1977. It consists of a 21.5 hp Lister diesel engine, a decorticator (dehulling machine, Fig. 1) and a Skjold hammer mil (Fig. 2) capable of grinding about 100 kg/hr and costing approximately $1K. All of this equipment is contained in a 4m x 7m corrogated sheet metal building. Women deliver the grain at one window and retrieve flour at another. Other equipment in the building includes scales for measuring grain input and flour output, calibrated diesel fuel tanks, a table for keeping records, and tools.

The system operates 5 days a week from 0730 to 1230 and from 1500 to 1800 hours. It is customary across the Sahel to take a 2- to 3-hour lunch period due to the extreme heat during mid-day. Often the mill operates overtime on Friday for women wishing to have grain ground for the weekend. The next

nearest mill is approximately 3 km from Ndiamsil. Women from other villages also bring millet and sorghum to be ground at Ndiamsil. A charge of 6 Fr (CFA)/kg (2.5¢/lb.) is made for dehulling, 7.5 Fr/kg (3¢/lb.) for grinding, or 12 Fr/kg (5¢/lb.) for both operations. Initially women brought 2-3 kg each for dehulling and grinding, but are now bringing 4-5 kg each.

As part of this project, an extremely thorough study is being carried out to determine the socio-economic effects of the system on the village. A 45-question questionnaire is filled out for every women bringing grain to the mill. Questions range from her name and address through why she uses the mill, her satisfaction with the project, what she does with her freed time, etc. Many of the questions are rephrased to insure consistent answers. Additionally, a large data sheet is maintained at the mill containing customer identification, type of grain, moisture content, weights and charges, and time in and time out for each operation.

To further understand the women's use of time, a 1/4-hour interval time-motion study is being conducted with a small sample of women in Ndiamsil from 0400 to 2100 hours every day for a year. Similar data is being taken on a random basis for a larger number of women in the village. Also, a cardio-vascular study is being planned for a sampling of women to determine the effects of the exercise they will not now get from dehulling and grinding (both are strenuous pounding operations carried out by mortar and pestle).

The milling facility is operated by a team of mechanics/ technicians trained both in operation and maintenance of the equipment and completing the questionnaires and taking other necessary data.

The villagers do not appear to object to the noise of the diesel engine and have, in fact, been observed to use the noise as a sort of clock around which they are scheduling their activities.

Another item of interest in the village was a small grain storage facility designed as part of the project and which costs about 8000 Fr (CFA)($33) and which is capable of storing 400 kg of millet (Fig. 3). Also, the women put on a small traditional threshing and dehulling demonstration for us.

The system at Sonkorong contains a 16.5 hp Lister diesel engine also driving a dehuller and a 100 kg/hr output hammer mill (Fig. 4). The building containing the equipment here is larger (approximately 5 x 8 meters) and is of masonry construction with a metal roof and painted white inside and out. It also has windows where women deliver their grain and pick up their flour. The same data is taken for each woman using the mill as at Ndiamsil. Milling and dehulling costs here are 10 Fr/kg (CFA)(4¢/kg) for each operation and reflect a different local milling costs scale.

We witnessed, in this village, an interesting demonstration of millet grinding. Starting with slightly dehulled millet, a woman ground (pounded by mortar and pestle) millet for the noon meal. The millet is ground and sieved to yield three varieties of flour (very fine, fine and coarse) used for three different dishes.

Following our visits to the villages we had lengthy discussions with Lalonde and Miss Edna Loose, a graduate assistant from Purdue helping Lalonde with his socio-economic studies. Following, in summary fashion, are some of the points we discussed:

- o Prelude to post-harvest technology experiments: Lalonde believes that a study should precede the implementation of systems such as his and the one we're planning for Upper Volta. Factors to consider include

  - geographic relationships of post-harvest practices
  - social and economic benefits to be studied
  - social and economic benefits sought
  - type and amount of post-harvest technology to introduce vis-a-vis state-of-readiness of people (appropriate technology)
  - prevailing preservation/storage practices and productivity
  - possible effect of technology on male-female roles, especially when using mechanical threshing as this would remove threshing from home (woman's role) to field (man's role).

Considerable study was carried out by IDRC prior to village selection and experiment design.

- Continuance of system operation: both Lalonde and Loose believe that after CNRA disengages itself from systems operation the diesel engines may be the ultimate shortcoming of the systems because of lack of maintenance skills and parts.

- Measurement of effects: Lalonde feels that it may be 3 to 5 years, or even a generation, before the full effects of the systems are known. One interesting effect that has been noted, however, is that because of the availability of flour (or the ability to easily produce flour), children are "snacking" a lot more and family grain supplies are being depleted before the next harvest. This same effect was reported in Upper Volta where grinders have operated in rural areas.

- System costs: For the first three months of operation at Ndiamsil, the operation and maintenance cost (fuel, lubes, filters) amounted to $.023/kg of grain ground. (NB: we obtained detail system costs which are too voluminous to present here.)

We met briefly with Gora Beye, Director of CNRA. He indicated that the World Bank is interested in their post-harvest technology program. Replication of systems such as we observed is limited by available funds. As in most Sahel countries, funds will probably have to come from private or governmental donors.

Quite by chance we learned of and visited a new photovoltaic-powered village water pumping system 6 km from CNRA (Figs. 5 and 6). The system had been in operation only 4 days and judging from the activity at the spigots, was an obvious delight to the villagers. The system was installed by Pompes Guinard of France and contains a 900 watt 60 volt array of Solarex Model 4200 modules, a Guinard vertical turbine pump reportedly capable of lifting 80 m^3/day from 13 m standing water level, a 20 m^3 water storage tank, and a water dispensing facility. There is no instrumentation. The Guinard photovoltaic-powered pump systems are designated to run without energy storage. The system was estimated to cost $40,400 and was funded by a private donor in France. Village population was estimated as 1200 people.

The three days spent with Lalonde were extremely interesting and rewarding. In addition, his personal hospitality and the

cooperation of IDRC both in Canada (prior to our trip) and in Dakar was exemplary.

Ouagadougou and Tangaye, Upper Volta, February 15-24, 1978

We arrived in Ouagadougou the afternoon of Wednesday, February 15, and met briefly with John Hoskins, CDO, USAID, Upper Volta, to discuss our agenda for the duration of our visit and the status of the USAID paperwork relating to this project.

On Thursday we left at mid-morning for Tangaye and Fada N'Gourma arriving at Fada at about 1430 hours following a brief stop at Tangaye to view the well site. The remainder of the afternoon was spent discussing the socio-economic aspects of the project with Grace Hemmings, the anthropologist under contract to USAID for the photovoltaic project study, and in completing logistics arrangements for our site inspection. On Friday we visited Tangaye where we discussed the project with the village chief, presented him with pictures of he and his wife taken during last year's visit (which delighted all), pumped the well to determine its recovery rate, and performed a cursory survey of the well area. We returned to Ouagadougou that night at about 2000 hours. On Monday morning we met with Tom Luche, USAID Photovoltaic Project Leader, and Bill Erdahl, USAID Ouaga Deputy Program Officer, to discuss the language in USAID's "Project Implementation Order/ Technical Services" (PIO/T) draft. The remainder of the week was spent obtaining estimates from local contractors for construction of a water tank and water dispensing facility, obtaining cost estimates for transportation and storage of materials in Africa, discussing further the socio-economic aspects of the project and how they impact USAID's objectives and our measuring and reporting of system performance, visiting two milling operations in Ouagadougou, and inquiring as to local availability of pumps and grinders. Also, during this period John Hoskins indicated that additional funds might be available to augment this project.

The details of discussions with Grace Hemmings, the site visit to Tangaye, and project-related activites in Ouagadougou are presented below.

Discussions with Grace Hemmings

Miss Grace Hemmings, a U.S. citizen, has been living in Upper Volta for 3 years while working on her Ph.D. thesis

in Anthropology, "Adaptive Strategies to Drought." She started doing preliminary research in Tangaye in January 1978. The objective of her preliminary studies are to conduct a study to find out what organizational structures, traditional or otherwise, (e.g., cooperatives and extension services) exist within villages that may support the use of solar energy for water pumping and cereal grinding. The description of the scope of her technical service is as follows: the study will address itself to the management of water pumps and cereal grinding mills and the economic and social implications of operating solar energy powered units. The management aspects will deal with what infrastructure, traditional or otherwise, exists in the village, that may lend itself to operating solar units. If no such infrastructure exists, the potential for developing a capability within the village will be explored. Economic and social implications will also be studied to determine their impact on the local community.

In summary her findings are:

- At the 1973 census, 2375 people lived in the village in 188 extended family groupings. Her estimate is that the village population now is about 2700. She also provided us with a detailed breakdown of men, women, and children by tax status. Two significant facts emerge from the census data: (1) there were 451 women in the 18-60 year age group and these women probably do most, if not all, of the water hauling for cooking purposes; and (2) 72% of the men in the 20-29 year age group migrate to jobs (often outside of Upper Volta) during the dry season.

- The village has 5 agricultural groupments, run by and composed chiefly of older women, for the purpose of organizing the agricultural activities in the village. Grace believes that these groupments could form the basis for administering and maintaining the mill. She further believes that the women are better suited for this purpose than the men because they would have a vested interest in proper and continued operation of the mill.

- There are 3 mills in the area that women from Tangaye use. These are:

  - Diabo, 6 km SW of Tangaye: Since 1968 the mill has been replaced four times and each time has resumed operation under different ownership. When

equipment breaks down it is hauled out and replaced. The present mill, a large stone mill powered by a diesel engine, has been out of operation since December. This mill is reported to charge the lowest price in the area (20 [CFA]/ 4 liters)(8¢/4 liters). The grinding hours have been flexible ranging between 0600 and 2100. More grinding is done during the rainy season (end of April through end of December) reflecting the greater amount of time women spend in the fields during that season. Likewise then, most grinding is done in the afternoon. Without the mill, the women would have to grind at night during this season. The mill is particularly busy on market days (every third day). Incidentally, the 4 liter measure results from the days when the colonial French government taxed the people one tin (4 liters) of sorghum. Four liters of millet weigh about 3 kg.

- Tibga, 16 km NE of Tangaye: operated daily from 1972 to 1975 but only on market days now. The number of women using this mill has decreased of late due to increased milling charges resulting from increased fuel costs. Milling charges are now 25 Fr (CFA)/4 liters (10¢/4 liters). The Tangaye women most likely to use this mill are those who are vendors at the market at Tibga. Again, the period of greatest use is the rainy season and then mostly in the afternoon. Hours of operation are flexible, including mid-day if there is a demand. The millet ground here is mostly for the evening meal (≈4 liter/woman) and is run through the mill twice at no extra charge. Millet ground for dolo (local beer used at home and sold at market) and millet cakes (sold at market) is run through the mill only once. The mill has one recorded accident - an index finger chewed up in 1968.

- Gounguin, 8 km NW of Tangaye: the only information about this mill at present is that it includes a facility for dehulling rice.

o Other miscellany regarding milling: It was reported to Grace that the availability of milling facilities has increased grain consumption often causing family

shortfalls between harvest seasons. The women are usually responsible for paying for grain grinding. Grace is doing a time study to determine amount of time spent grinding.

- In regard to water, Grace has hired one assistant to help determine the amount of water drawn from the well and how it is used within (domestic) and without (livestock) the extended family grouping. She has already ascertained that livestock are very rarely watered from the well but rather from streams or pools near grazing areas. We have asked her to obtain additional information on the characteristics of the well during the wet and dry seasons.

We had lengthy discussions with Grace concerning how she could direct her studies and proposed management of the mill to effect the primary objective of the project, namely "to determine the socio-economic effects of reducing (women's) time spent in laborious tasks" (Bosken AID/OST, letter to LeRC dated 8/31/76). It did not appear that she had been given adequate direction to structure the socio-economic study to develop the data during the period of the experiment necessary to conclude her study or to enable us to analyze operating costs for the system (Re., NASA LeRC Draft Project Plan, December 16, 1977, paragraph 2.2.8).

We, therefore, drafted for her a sample data sheet for use at the milling operation.

We agreed that an equitable way to avail women of the milling service is to charge for that service. This would put the Tangaye mill on an equal footing with other mills in the area and would not undercut entrepreneurs in the area. Further, we suggested that the funds collected be used to employ a technician(s)/miller(s) who would take the daily data on the milling operation (e.g., date/time/who/from where/type and weight of grain/charges/etc.).

Charging for the milling service resolves, in a traditional and acceptable fashion, the question of who benefits from the mill. It does not, however, guarantee that the mill will be used so as to enable a valid socio-economic study. I believe that, in order to conduct the study, Grace will have to identify a group of women to study who are likely to be able to use the mill regularly. As we have seen, women from Tangaye walk to neighboring villages to secure milling services. We can expect, therefore, that women

from other villages will come to this mill. They can benefit the milling operation by ensuring a sufficient customer base to create a demand for full time operation. However, this may also complicate the socio-economic study. Grace will have to address those factors in her managemenc plan.

The question of who will have access to pumped water does not appear to be a problem. The pump we have purchased for this system is capable of delivering 1457 liters/hour. Based on the volume of water in the well at the time of our visit (6891 liters, which is approximately the maximum daily yield of wells in the Tangaye area - see Tangaye Area Well Data below), the pump is capable of pumping the well dry in about 4.7 hours. Our original system design anticipated approximately 10 hours/day of pump time to yield 13,113 l/day. Our measured recovery rate is 4800 l/day.

Given that part of the village draws from this well all year and that all of the village draws from it toward the end of the dry season (Re., trip report, Stone and Ratajczak, 2/77 and Luche, Telex, 12/15/77) it appears that we can meet the total traditional water demands placed on this well. It may happen, however, that women from other parts of the village will elect to trade a longer walk for pumped water against drawing water from a nearby well. Grace will have to be alert for and provide administratively for this possibility in her management plan.

Visit to Tangaye

Our visit to Tangaye was preceded the evening previous by a bit of extremely good news. During our visit last year, we discussed securing the services of Allen Clark, a civil engineer, for the period July 1977 through approximately January 1978, following his Peace Corp tour of duty. He was personally interested in the project and agreed at that time to sign a personal service contract with AID to help with site preparation and construction. When the project failed to materialize last year, we were led to believe he had left the area. As it was, he had signed on with AID for a rural roads development project in the Fada area. The roads project is under Luche's cognizance. On this trip he again accompanied us to Tangaye and helped with our pumping and survey work. He participated in our shipping and equipment estimates effort. With Hoskins' and Luche's consent he has agreed to help with site preparation, supervise construction of the milling building and installation of the water tank and any other preinstallation masonry work.

He is still personally interested in the project, understands what we are doing, and is a very welcome addition to the project.

We spent all day Friday, February 17, under the brain-baking sun (98° F in the shade) gathering site specific information. After first dispensing with the preliminary formalities with the Chief and his council we proceeded to pump the well to obtain an estimate of its recovery rate. The two 12 VDC bilge pumps we took with us, when connected hydraulically in series, pumped at 1500 liter/hour which nicely approximated the 1343 liters/hour capability of the pump we have purchased for this project. Our original plans were to pump for a couple hours, but a shortage of fuel for our Land Rover vehicle, which we were using to power the pumps, limited pumping to 1/2 hour. We measured the recovery rate for one hour. The data indicate a recovery rate of 4800 liters/day which approximates the 5000 liters/day estimate from the Rural Engineering Service (Luche, Telex dated 12/15/77 and Tangaye Area Well Data, below). The well characteristics and results of the recovery rate tests are shown in Figure 7.

We later showed the Chief's wife and other village women samples of flour ground from the sorghum Luche had sent us. The flour was ground at the LeRC using the Bell Company burr mill we have purchased for this project. Very discriminating women these. They were able to feel differences in flour from each grinding process. They agreed that flour twice ground with the very fine burrs was satisfactory, but were delighted with the thrice ground with very fine burrs set very tight. In fact, they agreed that the latter was finer than their normal stone ground flour. At the conclusion of our samples review, we offered the Chief's wife our sample bags with flour. She was positively delighted, not with the flour so much as with the zip-lock plastic bags.

Our discussions then turned to facility location and construction. At Grace's suggestion we (LeRC and AID) had previously agreed on tentative locations for all system components and presented these to the Chief for concurrence. He concurred. We then discussed construction of a building for the grinder. The Chief agreed that the village would provide labor, mud bricks, mortar, and thatch for a building approximately 4m x 5m. We would provide miscellaneous hardware, framing lumber, and metal for doors, windows, etc., concrete for a base for the grinder, and cement to firm up the packed earth floor they proposed.

We finished our day at Tangaye by performing a crude survey of the area near the well using my camera with a telephoto lens, a line level atop the camera, and a carpenter's rule.

Ouagadougou, February 20-23

February 20 was both a U.S. and Upper Volta National holiday - President's day for us and Mohammed's birthday for others. Nevertheless, we met with Luche and Bill Erdahl for about 3 hours to discuss the PIO/T. The remainder of the time spent in Ouagadougou was given to several activities:

- Water Tank/Dispenser: We visited three metal fabricators to obtain estimates on a 5.7 m^3 water tank with a dispensing facility and a 11.4 m^3 tank with dispensing facility. Allen Clark accompanied us on the visits explaining to the fabricators our requirements and the sketches we had prepared, and obtaining from them other information regarding their operations. We visited them the following day to pick up their estimates which were:

Manufacturers	5.7 m^3	11.4 m^3
SAFI	$3211	$5025
A.C.M.D.	2319	4431
A.B.F.	1849	2461

All estimates include engineering drawings to be prepared by the contractor from our sketch and specification and to be approved by us prior to construction, red primer outside paint, epoxy painted interior, and delivery to Tangaye. (We would supply the epoxy paint.)

- Equipment Transportation: We likewide visited (one day) and obtained (the next day) two estimates (one is still outstanding) for shipping costs for our material from the port at Abidjan to Ouagadougou, unpacking the container and storage in Ouagadougou, and trucking to Tangaye.

	Shipping to Ouaga	30 Day Storage	Shipping to Tangaye
SAG	$1105	$244	$488
SOCOPAO	1386	15	612
SOVOG	--	--	--

All three conceded normal time from off-boat to Ouagadougou is three weeks but is contingent on rail car availability.

- Tangaye Area Well Data: We met with Dominique Batio Ido, Directeur, Direction Hydraulique et Equipement Rural, Ouagadougou, and discussed the results of our pumping at Tangaye. He indicated that 10 m deep wells in the Fada (Tangaye) area normally yield about 5 m^3/day. Deepening the well to 20 to 25 m at a 1.2 m diameter would increase its capacity to 6 to 7 m^3/day. If it were deepened to 40-50 m (drilling), it would probably yield 10 m^3/hour and water would be within 10 m of the surface. However, they have no plans or money for improving the Tangaye well this year or next. Presently, their major well improvement program is centered in the western part of the country. They did agree, however, to pump the well at Tangaye completely dry, measure its recovery rate sometime before April 1, and provide the information to Luche who will forward it to us.

- Additional Funds: John Hoskins indicated in the course of our discussions that he could possibly obtain additional funds for this project from their Accelerated Impact Program (AIP) funds. These additional funds would be used for increasing the grinding capability of the system and to cover LeRC participation for 1 year following initial operation (Hoskins decided that the experimental period for this system would be one year). Accordingly, we formulated a preliminary supplemental funding requirement based on the estimated additional array and battery necessary for 8 hours/day of grinding (up from 5-1/2 hours/day previously), increased shipping costs based on preliminary estimates of in-Africa costs, a spare grinder and additional spare parts, additional installation costs and LeRC manpower costs. Hoskins indicated a final decision on additional funding should be reached by April 1.

- Miscellaneous: We visited two commercial grinding facilities in Ouagadougou (Figs. 8 and 9). Most appalling was the lack of safety considerations - people with loose clothing and children around equipment running from unguarded flat belts, and a stone mill so badly out of balance that we expected it to disintegrate momentarily. Nevertheless, both facilities were quite busy.

We found one store that sold 300 mm diameter stone mills of French manufacture for about $400 and which would require at least a 2 hp motor. The dealer apparently sells quite a few in the Ouagadougou area, mostly to commercial millers and wealthy individuals. Based on our observations of operative and nonoperative stone mills, we decided that durability and continued operation of our milling system would probably be best served with our burr mill, albeit at a price of reduced throughput. We surveyed one dealer of pumps and found nothing suitable (DC powered) in stock or in his catalogs although he had information on a vertical turbine pump to which a user could attach a motor.

In summary, this trip was very productive. In Senegal we gained considerable insight into the operation of milling systems and in particular, the conduct of socio-economic studies of milling systems.

In Upper Volta, we obtained site specific engineering data needed to establish technical and operational requirements; received assurances from Allen Clark of supervision assistance during construction and installation; visited local water tank fabricators and received price estimates; obtained in-Africa shipping and storage charge estimates and worked out PIO/T language.

Further, we addressed major technical and procedural questions of concern to NASA. Based on our tests at the well, I believe that the water benefit issue is resolved. As to the issue of milling benefits, we did articulate our concerns regarding benefits and study results to Hoskins, Luche, and Hemmings and, in the course of our discussions, developed a possible equitable solution. Disposition of the outstanding questions on the milling operation should be made in the anthropoligist's base-line socio-economic study management plan.

The matter of funds needed to cover LeRC manpower, travel, data analyses and report preparation through the period of system operation (i.e., 1979) is yet to be worked out by AID. If, however, Hoskins can obtain AID funds, as discussed above, this matter would be resolved.

Anthony F. Ratajczak

APPENDIX A

PRELIMINARY SUPPLEMENTAL FUND ESTIMATE FOR TANGAYE SOLAR ENERGY PROJECT*

Additional services and hardware that could be provided if supplementary funds are available from AID:

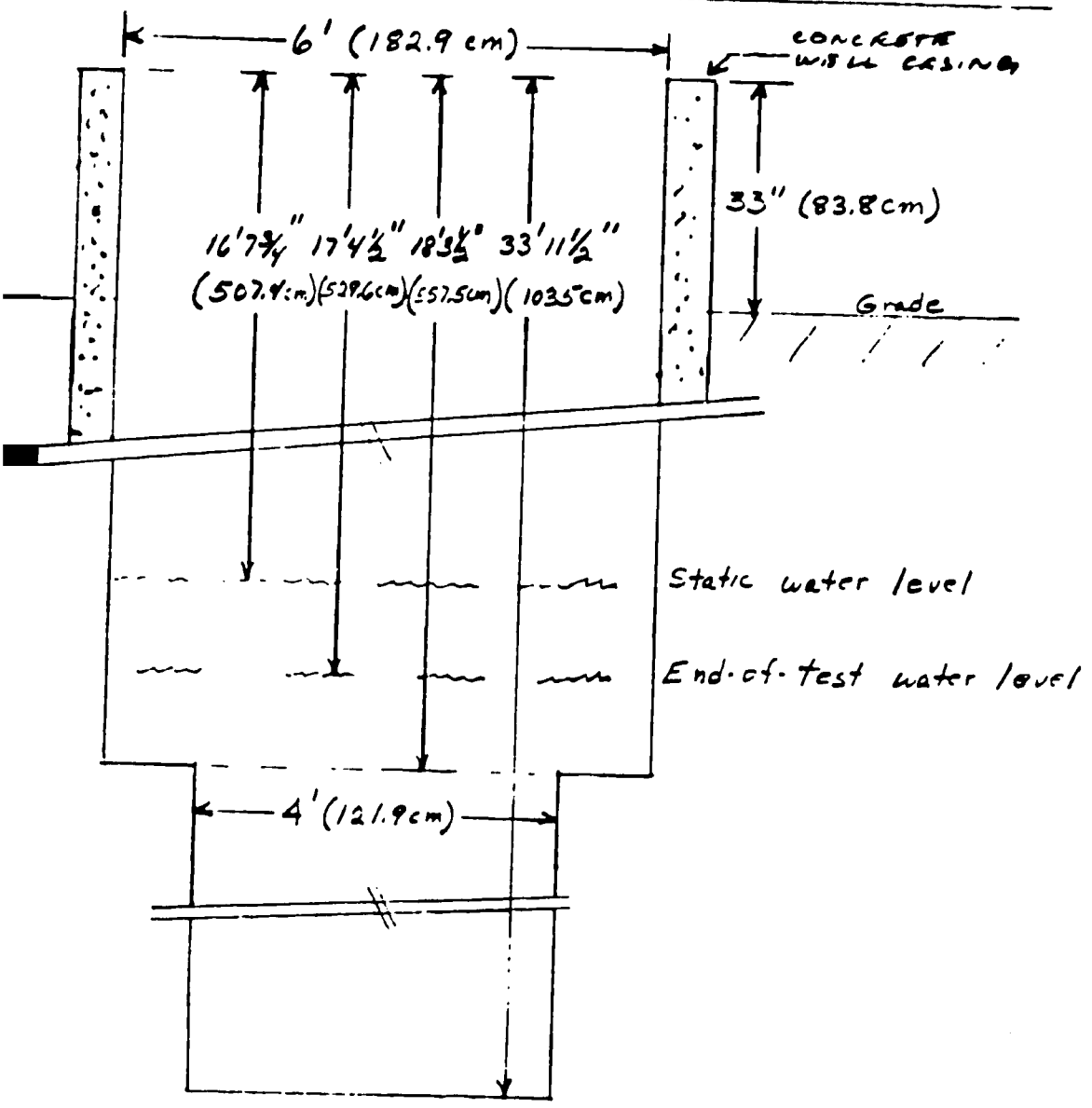
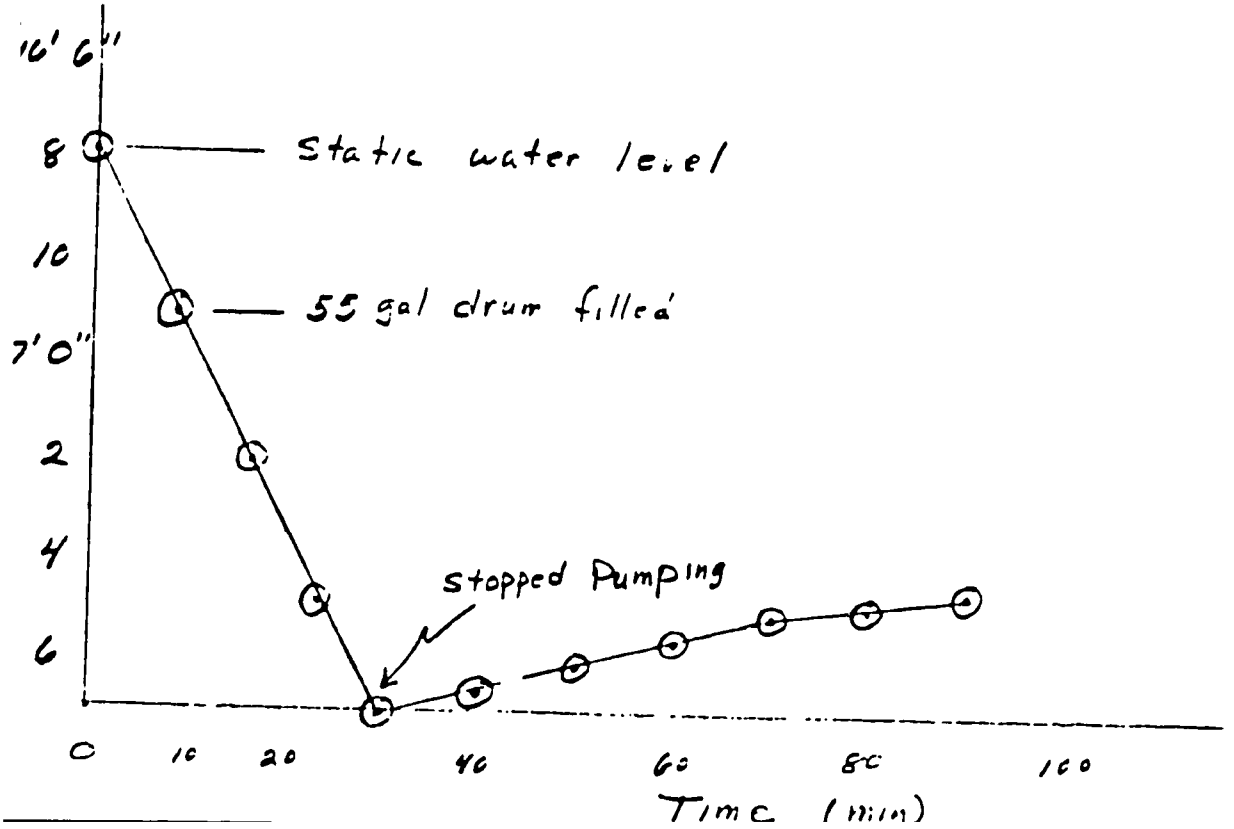
- Milling time increased from 5-1/2 hr/day to 8 hr/day.
- One year of system operation, monitoring and reporting by NASA; i.e., for duration of experiment.
- Spare grinder and additional grinder and pump parts.
- Materials and weighing scale for milling facility.
- Rural Engineering Service (HER) well test

Cost:

Additional solar array, batteries, etc.	$22,518
Additional travel	8,381
Spares and spare parts	709
Budget for battery shipping failures	500
Ouagadougou water tank additional	2,750**
Shipping update and additional	1,507
Milling facility materials	650
Well test	400
Reporting and LeRC manpower	15,600
	$53,015
+ 10% contingency	5,302
	$58.317

*Provided to John Hoskins, CDO, USAID, February 1978.
**This estimate was compiled before we had received estimates from local manufacturers.

FIGURE 7

Tangaye Well Characteristics

22 Feb 1978
NASA - LeRC
(Rev 3/22)