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TECHNOLOGY DEVELOPMENT FOR THE BRET PROJECT:

A CONSULTANCY REPORT

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PREFACE

This report presents the activities and scope of work undertaken by Mr. Ron Alward, a solar engineer consulting for Associates in Rural Development, Inc. (ARD), from October 21 through November 21, 1982. In addition, this report details a number of Mr. Alward's suggestions for directions of future work at the Botswana Renewable Energy Technology (BRET) project. The initial scope of work outlined for his consultancy is given below.

1. Review technical designs and prototypes of village technologies, including solar stills, solar water heaters, stoves, evaporative coolers and biltong dryers.

2. Establish testing criteria and procedures for village RETs.

3. Develop solar oven designs and plans for prototype construction.

4. Assist in the design and plans for development of village training facility.

5. Adapt David Norris' small passive housing/building designs from Lesotho for use in Botswana.

6. Assist in the establishment of technical direction for the project.

7. Additional technical assistance, as determined by counterpart project coordinator.

8. All of the above will be carried out in conjunction with the counterpart project coordinator and other staff, as required.

9. Provide a draft report, covering the above items, to the RET project before departing Botswana and a copy to the ARD office in Burlington, Vermont upon return to the United States.

I. OVERVIEW OF ACTIVITIES

Upon arrival in Gaborone, discussions with project staff identified priorities in the scope of work. The principal effort was to be directed toward three specific areas:

- design, planning and initiation of construction for the first Village Training Facility (VTF) in Ditsbegwane;
- review of designs and prototype installations of batch solar water heaters and the photovoltaic installation at the clinic in Lentsweletau, and assisting with installation of monitoring equipment for these prototypes, if available; and
- assisting in the development of a consultant timetable for the next 12 months--a part of this was to involve an assessment of staff technical capabilities and provide assistance in establishing technical priorities.

The first item combined numbers 4 and 5 from the original scope of work. The second contains elements of numbers 1 and 2 in the original scope of work. The third includes number 6 from the original scope of work. No effort was made to do any development work on solar ovens, stoves or dryers. In addition, technical and other assistance was provided in a number of relevant project areas, which are briefly discussed in the following section. All work carried out as part of the above scope of work was undertaken in conjunction with the counterpart project coordinator and other BRET staff.

A. Work Undertaken

1. Plans were developed for rondavel and rectangular buidings as part of the VTF at Ditshegwane. The rondavel is to house the village facilitator, and the rectangular building, classroom space and indoor training facilities. Both buildings incorporate passive solar design for the significant summer cooling requirement and nighttime winter heating. David Norris' small passive housing/building designs for Lesotho and Blair Hamilton and Ron Alward's earlier work on passive buildings, also from Lesotho, were used.

Negotiations were held with the Village Development Committee concerning labor and materials for the VTF, and construction was begun on the rondavel prior to Mr. Alward's departure. Building plans were submitted to the U. S. Agency for International Development (USAID) mission architect for approval and were discussed with Derek Medford of the Botswana Technology Centre (BTC) and the District Planning Office in Galepolale. Approval was obtained at all levels for these designs.

2. The batch and continuous water heaters constructed by project staff were reviewed, and additional design suggestions made. Experimental procedures for determining system efficiencies and the information required for adequate records on each water heater developed were outlined.

Plans for the prototype photovoltaic installation in Lentsweletau were reviewed with BRET and BTC staff. Because the monitoring equipment was in transit, it was decided not to concentrate on a detailed monitoring program as part of this consultancy.

The technical designs for several other prototype village technologies, developed and/or constructed by BRET staff members, the Rural Industry Innovation Center (RIIC) and others were also reviewed. These included solar stills, evaporative coolers, earthen stoves, and windmill and hand pumping systems.

3. Discussions were held with project staff and other relevant technical persons in Botswana in an effort to define both the immediate technical direction of the project and where technical assistance would be most effective. Section II of this report, "Technical Direction of BRET Project," presents a consensus reached with the project's technical staff concerning a prioritization of activities and the short-term need for further consultant input over the next six to 12 months.

4. Some time was spent with BRET staff, and by telex with ARD's business manager Richard Hart, on equipment procurement.

5. Site visits were made to Ditshegwane, Strosborg, Kanye, Ramotswa and Serowe on project-related matters.

B. Contacts

People contacted during the consultancy, other than BRET project staff, are listed below.

Contact	Affiliation	Subject of Discussion(s)
Bart Aarsse	BTC	BRET/BTC relationship, photovoltaic water pumping and clinic electrification, RIIC windmill program, ARD/TEA-designed house currently under construction.
Derek Medford	BTC	BTC approach to technology innovation, BRET/BTC relationship, BRET project prioritization, VTF budget, RIIC windmill, final VTF building plans.
Viera Larsen	private architect	Her study (to be published in Sweden in English) on traditional houses in four villages in Botswana--documentation of how the traditional house is built and used.
Bill Karg	Self-Help Housing Agency (SHHA)	Review of SHHA house types, profile of occupants, availability of materials, skills.
Paul Tuebner	USAID	General project concerns, contacts.
Stafford Baker	USAID	Necessary plans for VTF buildings.
Laurie Mailloux	USAID	Latrines.
Jim Wilson	ESPP	BIT latrines, materials, construction techniques.
Anna Nkwe	RIIC	RIIC solar and wood cookers.
Kit Morre	RIIC	BRET/RIIC/BTC relations, RIIC technical and extension activities.

Contact	Affiliation	Subject of Discussion(s)
Isa de Vries	RIIC	Technical drawings, animal-driven pumps, RIIC and Serowe windmills.
Max Ewen	RIIC	RIIC windmill construction, testing, operation.
Sonja Barrett	RIIC	RIIC solar still and solar cooker work.
Ed. de Santos	Serowe Windmill Technical Group	Site inspection and status of Serowe windmill project.
Case Flink	MRWA (newly arrived from Holland)	Coordination of his work with Jack Shields' activities.
Moses Lekaukan	MRWA Deputy Permanent Secretary	Debriefing on consultant activities.
Hank-Olaf van Lieuwer	Tswelelopole Brigade Centre, Ramotswa	Technical drawings of VTF.

C. Design of VTF Buildings

The two main structures to be built at the VTF in Ditshegwane were designed for the dual purposes of housing the training facility and facilitator, and demonstrating simple, low-cost, energy-conserving and passive solar-heating techniques. Ordinary building materials and construction methods were used in the designs. The major design concerns were user comfort and improved maintenance characteristics. The final drawings of the VTF buildings are being prepared by the Tswelelopole Brigade Centre in Ramotswa; when completed, they will be available through the BRET project's headquarters in Gaborone.

Site Plan

The plot of land allotted by the Village Development Committee is roughly square, 45 meters on a side and situated immediately north of the site of the Kgotla and other village-owned buildings. In keeping with traditional family yard plans, the two buildings were grouped about one-third of the way across the yard from the main entrance through the fence, in such a way that each building's major doors face a lelwapa. The lelwapa faces the main fence entrance, and thus, the doors also generally face that direction. The buildings have been spaced so that no part of the southern structure is shaded by its neighbor when the sun is lowest in the northern sky. A latrine is located 10 meters behind the two main buildings.

The VTF site is not centrally located in the village. However, its location relative to the village Kgotla gives it a prominence that should be a significant advantage in its role as a demonstration site. The VTF buildings are described in the following two sections.

The latrine selected for construction at the site is the ESPP project's BIT latrine, specifically adapted, under the direction of ESPP's Jim Wilson, for use in Botswana. Plans for this latrine are available from the BRET project.

Rondavel

The rondavel is the traditional and most common house form in the country. In many villages, it is virtually the only type of structure in evidence. The rondavel is a thermally efficient building, if well built, and is well adapted to Botswana's climate and housing needs. It provides a cool space, protected from the hot summer sun, in a relatively compact volume that can be fairly easily heated during the two cooler winter months. However, the rondavel's function as a warm winter shelter has been down-played by occupants in many parts of the country, perhaps because the concern with summer cooling far outweighs that with winter comfort. There are two major reasons for looking again at comfort levels which can be attained in a rondavel, particularly in Botswana's rural areas:

- fuelwood is becoming scarcer in many parts of the country and any space heating with this fuel exacerbates the situation; and
- the existing structure can be easily and inexpensively upgraded to provide increased winter comfort with only slight adaptations of traditional practices.

The chart on the next four pages lists the improved features which the VTF demonstration rondavel in Ditshegwane will incorporate, along with each feature's advantages and disadvantages. The major improvements to the rondavel, which is currently under construction, relate to the use of passive solar heating and reducing heat loss during

Improved Features Incorporated in VTF Rondavel - Litshegwane

	Advantages	Disadvantages
1. Select site to have no winter shading.	--unobstructed entry of sun through windows in winter	
2. Orient rondavel so that windows are facing north to northeast.	--lets in early morning sun in winter --heats interior throughout day	--windows face same direction as prevailing winter winds. --may not face part of yard occupant wishes to view
3. Add more windows or make windows larger than usual.	--lets in more sunshine in winter for passive solar heating --permits ventilation in summer --brighter interior (disadvantage?)	--decreases privacy --increases winter night heat losses if not curtained or shuttered --increases cost --need for lintel across top of window
4. Use wood window/door frames.	--wood conducts less heat either in or out than metal frames --easier to attach weather stripping to wood than metal frames	--lack of local availability of carpenter-quality lumber
5. Install windows toward outside of block wall.	--more winter sunlight enters glazed area rather than being blocked by recess	
6. Use blankets or insulating curtains over inside of doors and windows during winter nights.	--reduces radiant cooling of interior during winter evenings and nights --increases apparent thermal comfort --curtains/blankets help maintain privacy	--extra cost

	Advantages	Disadvantages
7. Use exterior shutters for windows.	--in closed position they reduce winter night heat losses --can help reduce daytime heat gains during spring and fall seasons --help to maintain privacy.	--extra cost --local materials not suitable to make wood shutters
8. Reduce overhanging thatch eaves above windows to north and northeast.	--lets in more sun during winter --reduces roofing materials required	--sacrifices some spring and fall shading effect --less protection of walls from splashing rain
9. Use thicker wall.	--increases lag time of heat pulse through wall to interior in winter, thus giving thermal comfort later into night --adds marginal insulation value	--more block material required --more time required during construction --heavier work lifting blocks
10. Paint or cover north wall with a dark coating.	--permits absorption of more solar radiation in winter --a larger pulse of heat passes through the wall in winter --a dark absorbing surface provides a warm outside surface to stand against early on winter mornings --provides increased exterior wall protection	--the dark color may not fit in with occupants' aesthetic and other needs --extra yearly maintenance to maintain dark surface over a natural-colored surface
11. Use dark-colored interior walls and floor areas where winter sun falls.	--absorbs sunlight and converts it to heat better than light-colored surfaces	--causes darker interior --may mean increased yearly maintenance

	Advantages	Disadvantages
12. Paint or cover west and south walls (exterior) with a light-colored coating.	--reflects summer sunlight and thus reduces cooling-season heat gain --provides increased exterior wall protection	--the light color may not fit in with occupants' aesthetic and other needs --extra yearly maintenance to maintain colored surface over a natural surface
13. Plant vegetation against west wall.	--provides shade against afternoon sun in summer	--requires watering --may not conform to occupant needs to maintain vegetation-free area near house
14. Increase thickness of roof thatch.	--reduces winter heat loss and summer heat gain --increases protection against rain --can provide a longer lasting roof between repairs	--extra cost and materials --new installation techniques may be required --lack of easy availability of thatch grass
15. Use insulation bags in gap between roof and wall.	--reduces winter infiltration and draft --reduces incidence of pest entry over the wall --if seasonally applied, does not affect summer ventilation	--easier access for termites to roof (Is this true?) --added cost/materials --problem of summer storage of bags
16. Weather-strip door and windows with animal skin.	--reduces infiltration of cold air during winter	--other priorities for animal skin --lack of good-quality animal hide treatment techniques

	Advantages	Disadvantages
17. Use a raised door jamb at threshold.	--reduces entry of cold air under door	--difficult to sweep dirt directly out of house interior --extra caution required upon entering/leaving doorway
18. Raise floor level above ground level.	--protects interior from wet ground	--extra time/labor/ materials
19. Add cement mix to exterior wall treatment.	--helps provide a longer lasting exterior surface, thus decreasing maintenance	--extra cost

those months when interior space heating is needed. The dominant cooling features in the traditional house--thatch roof and adequate interior cross-ventilation--have not been altered, except to increase the amount of thatch insulation in the roof.

There is a provision in the design to utilize removable insulating bags (plastic or jute bags filled with thatch) to fill the traditional gap between roof and wall, found in all the houses in Ditshegwane, in order to cut down on a major area of heat loss in winter. Once the benefits of temporarily closing this gap in winter have been adequately demonstrated in the VTF rondavel, a more permanent closure will be tried.

Discussions with BRET staff, and others concerned with rondavel design and use, lead to the conviction that the roof-wall gap may be an unnecessary feature, particularly if other means for adequate cross-ventilation are provided, perhaps by the strategic placement of doors and windows. The gap also provides a minimal level of daytime lighting; but again, windows can meet this need. Other villages throughout Botswana have rondavels both with and without the gap. Those without typically incorporate a door and window on opposite sides of the structure to provide summertime ventilation. Thus, this "innovation" in Ditshegwane is

not a new idea--it is simply the transfer of a well-accepted practice from one area of the country to another.

Rectangular House

The second VTF building is typical of the Self-Help Housing Agency's (SHHA) low-cost houses found in urban areas, such as Gaborone, Selebi-Phikwe and Francistown. The particular L-shape chosen represents two successive additions to the basic, 3 meters x 3 meters, concrete-block, one-bedroom module. The three-module size was chosen to provide ample interior space to house the facilities and equipment related to VTF training activities. Siting and other low-cost modifications to the basic design were made using plans, specifications and concepts adopted by the Lesotho RET project for low- and medium-income housing.

Some particular passive-solar and energy-conserving elements of this building that are worth noting include:

- north-facing solar aperture which is at least 10 percent of total floor area;
- major facade of the building faces north;
- non-glazed portion of north wall is made of a double layer of solid concrete blocks to provide both a larger thermal mass and increased lag time for heat absorbed by the exterior surface to pass through to the building's interior;
- adequate operable windows and doors for cross-ventilation;
- wood window and door frames, and wood door for improved insulation;
- windows installed toward exterior edge of wall;

- sufficient overhang on north facade to provide aperture shading during spring, summer and fall;
- north exterior wall painted a dark color for better absorption of winter solar radiation;
- dark-colored interior floor for better absorption of winter solar radiation passing through windows;
- light-colored east, west and south walls to reflect summer sun;
- vegetation planted against west wall to shade it from summer afternoon sun;
- layer of ceiling insulation and ceiling below corrugated iron roof to reduce winter heat loss and summer heat gain; and
- weather-stripped doors and windows.

II. TECHNICAL DIRECTION OF BRET PROJECT

This section provides an assessment of what activities should be undertaken over the next six to 12 months to enable rapid progress in future technology development and implementation. Included is a suggested priority level for each technology or project. The development of this list of activities and their prioritization was carried out in conjunction and with the active participation of the counterpart project coordinator and members of the project's technical staff.

A. Windmill/Hand Pumping Program

1. Wind Monitoring Program -- high priority

   a. Work with Mr. Case Flink of Water Affairs to coordinate network of 34 anemometer sites.

      --Clarify project role in national wind monitoring program.
      --Select sites, based on need for water pumping, Meteorological Service needs, present windmill sites and criteria given in project paper (under 500 people and 100 cattle), plus potential wind availability and population density.
      --Obtain concurrence from various ministries on sites selected.
      --Install one anemometer each at VTFs in Shoshong and Ditshegwane.
      --Train cooperating agency personnel in anemometer installation, operation and maintenance.

   b. Work with Meteorological Service and UB personnel to ensure that data analysis includes reducing data to meet project's engineering needs for wind power systems.

2. Hand Pumping Systems -- high priority

   a. Continue work on installation of two additional hand pumps, to give a total of five pumps installed;

take over Water Services' 23 sites to collect data and monitor pumps for durability/problems.

b. Refurbish human traction pump acquired recently and work with original Water Services' engineer on any design/part modifications.

--Install in appropriate bore-hole.
--Estimate cost of fabricating new units in Botswana.
--Assess operation of installed unit to determine acceptability, discharge at given bore-hole depth, problems and success.
--Fabricate and install five additional units at sites chosen for pump capacity, possibly cattle posts.

c. Modify the human traction pump to operate with animal power and compare with system installed by RIIC.

3. Integrated Wind/Hand Water Pumps

a. Select eight villages with shallow wells that have less than 500 people and 100 cattle, total water head under 30 meters and are windy for a significant part of the year.

b. Investigate commercially available windmills with back-up hand pumping systems that are capable of pumping 4,000 to 6,000 liters per day from depths of up to 30 meters in an average wind regime of 3.5 meters per second.

--Windmills must not be experimental--they must be on the market today and have a proven track record.
--There must be no research element involved in their installation or operation.
--Cost per installed unit not to exceed P6,000.

c. Purchase and install eight windmill/hand pumping systems, one each in villages selected.

--Evaluate frequency and duration of need for hand pumps at these sites.
--Monitor water output to distinguish between water delivered by windmill and hand pump.

d. Train pumpers/mechanics in use/maintenance of wind/hand pumps.

e. Determine local potential for producing spare parts.

f. Coordinate activities with Mr. Case Flink.

4. Deep Bore-Hole Windmill Pumping System -- high priority

a. Do engineering and economic analysis of RIIC windmill based on results up to March, 1983, as per current agreement with RIIC. Assessment based on following criteria:

--length of time in continuous operation with no major or minor breakdown for maintenance/adjustment/repair;
--number of repairs involving temporary shutdowns over past six months, up to March, 1983;
--degree to which specified output was approached, i.e., 7.5 cubic meters at 100-meter head or equivalent;
--performance in high winds, i.e., does it brake, turn out of the wind properly, etc.; and
--whether economics of performance meet on better predicted performance, comparison with diesel-powered pumps.

b. Monitor prototype windmill development at Serowe Windmill Technology Group, as per project paper, and support this effort, if justified.

--Serowe hub and rotor design appear much stronger than RIIC unit. It also has advantage of being less complex, thus presenting potentially fewer breakdown problems.
--Serowe windmill is several months behind RIIC's in development.

c. RIIC windmill (and Serowe's when ready) will require minimum of six-month field trial with no breakdowns under continuous operating conditions (when wind is available). After field test, should evaluate regarding continued support.

--At end of successful six-month field test, assist in further field trials by possibly purchasing one additional unit.

--RIIC windmill is some three years from commercial readiness. Past experience with windmill development programs has revealed a startling number of problems arise once prototype is ready for field trials. Current state of readiness indicates there may be some problems with output, both in terms of total head and volume of water.

--Six-month field trial should reveal major problem areas concerning component durability under prolonged operating conditions.

Information to Record

1) Schematic and/or working drawings of each different water pumping system.
2) Materials lists and specifications.
3) Cost of materials.
4) Best estimate of labor to construct/install.
5) Fabrication/construction problems/changes.
6) Operating experiences (narrative description).
7) All test data.
8) Data analysis.
9) Any recommendations for future/field-work.
10) Field trial experience.
11) User and demonstration program experiences.
12) Experiences with training programs.

B. Solar Water Heaters

1. Inexpensive Batch Water Heaters -- high priority

These are intended for use by individuals/families at the village level.

a. Simple tin cans with tops that close, e.g., rectangular, five-liter, oil tins.

--Paint black.
--Build tin, wood or earth box with insulation on sides and bottom to hold one or two tins.
--Simple glazing in front of fiber-reinforced plastic, glass or ultraviolet-treated, poly film.
--Should tilt from horizontal, for water heating outside in summer, to vertical, for use behind a window in winter.
--Should be portable.
--Glazing should cover virtually same area as total front area of cans.

--Glazing lid hinged or hooked in place.

b. Plastic pillows made of black vinyl plastic film, locally manufactured plastic bag or possibly, sections of rubber track or car tires.

--Has to be black, preferably on all sides.
--Has to be leak-proof, yet easily opened for emptying or refilling.
--In summer, filled pillow can be exposed directly to sun with no glazing, container or box, or insulation.
--In winter or windy weather, pillow can be placed in box of appropriate dimensions, which is insulated with thatch grass and has glazed cover.

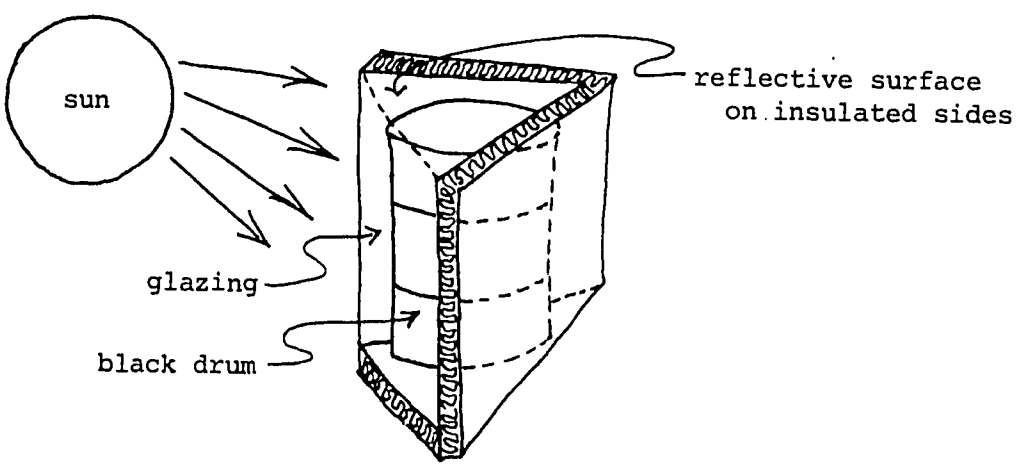
c. Shallow basin dug in ground.

--Lined with black plastic, or a pot or other container is set in hole.
--Pot or container must be black or dark-colored inside.
--Layer of plastic laid on water to prevent evaporation.
--Layer of plastic also put across top of basin or hole.

d. Water containers with exterior surfaces painted black.

--Expose to sun and shield from wind.
--Only good for summer use.

e. Two hundred-liter drums, painted black, glazed on north side and insulated on other sides.



2. Commercial Solar Water Heaters -- high priority

These are intended for use by institutions and urban home builders.

a. Less expensive, improved version of RIIC units or Solar Power water heaters, currently available in Botswana.

--Improvements over RIIC unit: indent metal fin before inserting and attaching pipe risers, attach risers with twisted metal hoops every 150 millimeters and use thatch insulation once properly developed.
--Continuous-flow unit, either pump-fed or preferably thermo-siphon.

b. Batch-type, such as Stewart Bentley has already built in Kanye.

--Flat black paint on 2 x 200 l drums.
--Plumbed in series with cold entering first drum at bottom, warm taken off top of first drum and fed to bottom of second drum, and hot withdrawn from top of second drum.
--Box built to house drums with glazing area equal to projected drum area. If glazed area is larger than projected drum area, ensure that all surfaces inside box are painted black to absorb solar radiation and convert it to heat.
--Insulate bottom and sides of box.
--Use long-lasting glazing to cover front of box, preferably glass or ultraviolet-treated, fiber-reinforced plastic.
--Drums mounted side by side, either vertically or at optimum yearly tilt.
--Double-glaze to retain more solar heat gained and reduce night heat loss, or single-glaze and use external, insulated shutter for nighttime heat retention.
--Can be installed with several drums in series, with four or five as the likely optimum.
--System is suitable only for connection to water main or another water system that forces cold water in as hot water is withdrawn.

Activities

1) Evaluate need for heated water at family/institution levels--survey clinics, schools, people in villages.

2) Determine suitable, available materials for use as solar water heaters, e.g., simple flat cans like food-aid or oil tins, thatch insulation and glazing materials people are familiar with.

3) Materials and labor costs.

4) Estimate economics of system operation/maintenance.

5) Run efficiency tests.

6) Batch and thermo-siphon efficiency testing:

--measure solar radiation intensity for duration of heating period at plane of collector;
--calculate total--direct and diffuse--energy falling on collector glazing;
--measure quantity of water being heated;
--record start-up and final water temperatures; and

$$\text{--efficiency} = \frac{m\ Cp\ \text{delta}\ T}{\text{solar rad. intensity} \times \text{collector surface area}}$$

where m is the water's mass, Cp is water's specific heat, and delta T is found by subtracting the starting from the final water temperature; units in numerator and denominator must be compatible.

These efficiency tests give a measure of overall system efficiency, i.e., the heating and storage of hot water. Thus, if water is allowed to heat for several hours and reaches elevated temperatures, system losses will be greater and so efficiency will be less. Also, the longer the heater is left in storage with little or no heat input (e.g., late afternoon or after sunset), the more losses will reduce the system's apparent efficiency. In order to obtain a reasonably accurate idea of how various systems work relative to each other, run the efficiency tests for some preset temperature elevation (e.g., an average delta T of 20°C) or, alternatively, use an appropriate time duration of three to five hours, being sure the test ends before 1600 hours.

In batch and thermo-siphon water heating, temperature stratification will occur in the water containers.

Attempts to de-stratify may cause heat losses that cannot be measured. Thus, it may be necessary to record temperatures at several vertical locations through the volume of water.

Information to Record

Information should be recorded starting at the outset of work on each heater, retroactive to beginning.

1) Schematics and/or working drawings for each water heating system.
2) Materials lists and specifications.
3) Materials costs.
4) Best estimate of labor in terms of time and money.
5) Fabrication/construction problems or changes.
6) Operating experiences, narrative description.
7) Test data.
8) Data analysis.
9) Recommendations for alterations, fieldwork, etc.
10) Field construction/operation experiences.
11) Interest of people/institutions in systems.

C. Thatch Insulation Program -- high priority to initiate

1. Examine thatch grasses, both traditional and European types, plus other common types, for thermal insulating properties in various densities and configurations (e.g., all grasses parallel, criss-crossed layers, tightly compacted, loose).

2. Investigate various treatments to render thatch insect-proof, fire retardant or resistant, and resistant to biological decay, including the use of Borax, various dip treatments and sprays.

3. Investigate techniques of preparing thatch as insulation. For example:

   --leaving it loose;
   --weaving into mat form;
   --sandwich of thatch and aluminum foil into flat boards, as per project paper annex IV-2; and
   --using it as a lightweight aggregate in a cement thatch and other lightweight organic or inorganic material mix.

4. Undertake durability and longevity tests under accelerated laboratory conditions and in field

trials. (Can Sonja Barrett's oven at RIIC be used for accelerated life tests?)

5. Develop techniques of installation as compressed boards, loose, or chopped up and blown in.

6. Investigate special design features for ease of maintenance, and establish user installation and maintenance.

7. Investigate thatch production in terms of growing techniques, places to grow and as a cottage industry.

8. Study economics of using thatch as replacement insulation for commercially available products.

9. Examine where thatch can be grown in Ngamiland, Kanye, around Serowe/Shoshong, etc.

10. Have stove consultant put some effort into developing techniques for quickly measuring thermal conductivity of various insulating materials.

Information to Record

1) Schematics and/or working drawings of each thatch/grass insulation system developed.
2) Materials lists and specifications.
3) Materials costs, including value of time to gather thatch.
4) Best estimate of labor required to fabricate.
5) Fabrication/installation problems.
6) Fabrication/installation/treatment experiences, narrative description.
7) Test data.
8) Data analysis and conclusions/results of thatch treatment procedures.
9) Recommendations for any changes in use, fabrication procedures, etc.
10) Field use experiences.
11) Individual and potential small business interest in using/manufacturing materials.

D. Evaporative Coolers -- high priority

1. Study of two systems already built/available is high priority.

--charcoal walls with upper pan of water
--enlarged earthenware jug (unglazed, fired clay)

2. Upgrade charcoal wall unit to make it function:

   --See Karen Village Technology Centre plans or others for complete details.
   --Closer fitting wall/door sections.
   --Use good grade of charcoal (not briquettes) throughout.
   --More permanent insulated bottom to avoid air leakage through chamber bottom.
   --Better wicking material from upper pan onto charcoal walls.
   --One day of work may be required to get cooler back in working order once new charcoal has been found to replace briquettes. If no new charcoal can be found, build a smaller cooler and use available, good-quality charcoal.
   --Simply keeping outer charcoal layers moist during two-hour period allowed an internal temperature reduction of 8°C. A properly constructed unit should permit at least a 20°C difference, if the ambient air has a low relative humidity.
   --Use different sizes of these types.

3. Experiment daily with both coolers to gain working experience with both.

   --Record ambient air temperature around cooler (indoors or outdoors, depending on cooler's location).
   --Record temperature in cool chamber.
   --Both temperatures should be measured twice daily, say at 0700 and 1500 hours.
   --Investigate quantity of water needed daily by each system.
   --Record quantity of food in cooler at times temperatures are noted.

4. Investigate charcoal sources to see if any is produced in Botswana, whether there is a suitable substitute, and if not, should the unit be abandoned.

5. After April, 1983, investigate other evaporative cooling techniques--pole or wide type, and night sky radiation.

6. Estimate materials and labor costs.

Information to Record

Information should be recorded starting at outset of work on coolers.

1) Schematics and/or working drawings of each evaporative cooling system used, including dimensions.
2) Materials lists and specifications.
3) Materials costs.
4) Time to construct/fabricate/maintain in daily operation.
5) Construction/fabrication/operating problems.
6) Operating experiences, narrative description.
7) Test data.
8) Data analysis.
9) Recommendations for alterations in future units and field trials.
10) Field construction/operation experiences.
11) Interest of potential clientele in various coolers.

E. Wood-Burning Stoves

1. Large Earthen/Mud Stoves (for inside or outside use) -- high priority

   a. Thoroughly investigate past RIIC experience, from 1978-1982.

      --See report on extension work by Anna Nkwe.
      --Discuss with her and any others, including researchers and interviewers, why stove program failed.
      --Poor extension, inappropriate technology, overly high expectations, other social or technical considerations?
      --Interview users with names and addresses from Anna Nkwe.
      --If problem was lack of regular, consistent follow-up, is it justifiable to try the approach again with better follow-through?
      --Stove too large?
      --Not enough wood fuel saved?
      --Are people really concerned about wood fuel shortage, or do they not perceive it as a problem.

   b. Reexamine whether or not large earthen/mud stoves are sensible in light of investigation's results.

   c. If they still make sense, carry on with mud stove construction and testing to gain experience in construction, modification and testing techniques. Experiment with various surface preparations/coatings (e.g., cement mortar mix, "fire" entire stove in portable kitchen) to render exterior surface durable.

d. Testing should follow recommended procedures, as per Howard Geller's report on VITA/ITDG testing. If the team prefers to await the stove consultant's arrival before beginning in-depth testing of each stove, then the simple tests that RIIC has used can be done in the meantime. (See RIIC report by Anna Nkwe.) Also, test fire, shielded fire and others.

e. Demonstrate large earthen stoves and portable wood-burning stoves in demonstration program at VTF over several days.

f. Along with this, work with two or three women in Ditshegwane who have already expressed interest in larger earthen stoves. Let them gain experience and make appropriate suggestions for alterations.

2. Open Fire with Windbreak (lelwapa beer brew stove)

a. Continue with existing trials.

b. Run experiments.

c. Can it be improved with addition of a reflector on inside curve of windbreak? Reflector can be sheet of galvanized iron (tin) that reflects heat onto side of cooking vessel.

3. Clay/Earthen Ovens -- second priority

a. Unit under consideration is most recent RIIC model using two truck wheel rims, welded together inside a large earthen body. Baking is done in oven at standing height.

b. Establish one such oven at each VTF.

c. Survey market potential for locally baked bread.

d. Survey villages (Ditshegwane and Shoshong immediately) for persons interested in baking bread as a business.

e. Bring one or two women from each village to RIIC for training for at least one week.

f. These women will then return to BRET's VTFs and run the ovens on a commercial basis.

g. The ovens will serve as both demonstration and commercial systems, hopefully stimulating spin-offs in other parts of Shoshong and other villages.

h. Pot lid oven over traditional fire.

4. Portable Wood-Burning Stoves -- second priority

a. Examine stoves being used successfully in Lesotho and other neighboring countries, e.g., jiko, chula, paola.

b. Buy or build stove models that appear promising, based on results of surveys to date, and offer brief familiarization with each stove by taking all of them to the first VTF for demonstration to villagers.

c. Demonstrate portable and large earthen stoves during program over several days at VTF.

d. Determine user interest in each stove type.

e. Encourage women to use various stoves during demonstration.

f. Select one or two stove(s) provoking greatest interest and work with a few village women over several weeks to refine the stove(s) to meet their specifications.

g. When stove(s) are ready, test using Mr. Geller's VITA/ITDG procedures.

h. Field test stove(s) with six families.

i. Depending on stove(s) selected, next step would be to either work with local people, training them to build the stove in their home; local entrepreneurs/fabricators, training them to fabricate and market the stove(s); or BEDU, the Brigades, PVI or RIIC to fabricate and market them.

j. BRET would provide necessary extension services, including technical assistance and follow-up with all users in VTF villages and possibly elsewhere, if the technology spreads. Such services would last several months to a year.

5. Hay/Wonder Box -- high priority

   a. Develop various models using different insulation materials:

      --cloth, blankets sewn into flap over quilted material,
      --straw in box with or without heated rock,
      --thatch-insulated boxes or baskets,
      --insulated pits dug into floor of rondavel, and
      --hay boxes purchased from the Republic of South Africa.

   b. Test each system's performance.

      --Ability to maintain adequately high temperatures for long enough period to complete cooking.
      --Measure temperature inside food container every five minutes using thermocouple probe to determine temperature decay rate.
      --Record ambient temperature (in room or outside, depending on box location) at same intervals to find the temperature difference driving the heat loss.

   c. System with slowest heat loss is best performer, but may not be most economic and/or acceptable.

   d. Determine user interest and preference by running demonstration program for one or two days.

   e. Select system receiving greatest interest and work with a few village women to refine the unit to meet their specifications.

   f. Field test system with six families, probably the families of those helping to develop the unit.

   g. Train local people in construction/fabrication and operation.

   h. Make necessary extension services available, including technical assistance and follow-up with all users over a period of several months.

<u>Information to Record</u>

Record information starting at outset of work, retroactive to beginning of project.

1) Schematics and/or working drawings of each cooking system used/developed/tested, including dimensions.
2) Materials list and specifications.
3) Materials costs.
4) Time to construct/fabricate/maintain/repair/operate.
5) Construction/fabrication/maintenance/repair/operation.
6) Operating experiences, narrative description.
7) Test data.
8) Data analysis.
9) Recommendations for alterations in future units and field trials.
10) Field trial and construction experiences.
11) User experiences, including satisfaction and frequency of use.
12) Training and demonstration program experiences.
13) Workability of extension program.

F. Photovoltaic Water Pumping -- second priority

Mr. Alward did not undertake any assessment of this program other than to speak with Bart Aarsse during his first week in country. However, he does suggest that one electric, submersible pump be tried to gain experience and for comparative purposes, and that ARD have someone in the United States do the design work.

G. Pedal-Powered Sorghum De-Huller -- very low priority

This technology is given a low priority for the next six to 12 months. Mr. Alward suggests reducing the number of grinding wheels to two from the four used in the earlier, now abandoned, RIIC, pedal-powered de-huller, and bringing in a consultant, such as Al Ulmer, to assist in technology development. A literature survey is currently underway.

H. Solar Cookers -- very low priority

Monitor RIIC activities.

I. Solar Stills -- second priority

Develop working relationship with Sonja Barrett of RIIC. BRET can help with extension work.

J. Photovoltaic Electrification of Rural Health Clinics -- high priority

a. Current status is that Lentsweletau clinic has to be electrified and BRET is presently awaiting monitoring equipment.

b. Two other health clinics are being sought for use in training technicians in all aspects of photovoltaic electrification, from design through installation.

c. No design activity will begin for these two clinics until the project has two months of data from the Lentsweletau site.

d. The two clinic installations are expected to be complete within six months of the initial two-month monitoring period at Lentsweletau.

K. Solar Dryers -- second priority

Needs defined in Ditshegwane survey. Initial steps to be undertaken immediately include a literature search and input from the extension team concerning more information from the villages surveyed on drying requirements--crops and quantities.