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BOTSWANA RENEWABLE ENERGY TECHNOLOGY PROJECT

SECOND-YEAR ANNUAL REPORT

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CONTENTS

Section	Page
Preface	i
I. Executive Summary	1
A. Major Accomplishments	1
B. Overview	4
II. Activities and Accomplishments	7
A. Energy Needs Assessment	7
B. Awareness Campaigns	7
C. Development and Demonstration of Village RETs	10
1. Wood-Conserving Stoves	10
2. Retained Heat Cookers (Wonderboxes)	13
3. Solar Hot Water Heaters	14
4. Other Technologies Researched	14
D. Research and Development of Institutional RETs	15
1. Water Pumping	15
2. PV Electrification	22
3. Solar Water Heating	24
E. Passive Solar Construction	24
F. Training and Institution-Building	25
1. U.S. and Third-Country Training for BRETP Staff	26
2. In-Country Training for BRETP Staff	27
3. RET User Training	29
III. Summary of Project Management and Administration	31
IV. Issues for the Future	33

Appendices:

A--Logical Framework	A-1
B--Summary of Project Activities by District	B-1
C--Map of Botswana	C-1
D--Acronyms	D-1
E--Publications and Reports to Date	E-1

PREFACE

The Botswana Renewable Energy Technology (BRET) project (number 633-0209) was approved by the U.S. Agency for International Development (USAID) in September 1980. Associates in Rural Development, Inc. (ARD) was selected and contracted in August 1981 to provide the technical assistance component of the project. In November 1981, the project coordinator arrived in Botswana with ARD's vice-president, Dr. James Nolfi, to begin ARD's project operations under the contract. The AID funding for the BRET project, which includes ARD's technical assistance, was scheduled for three years.

The first-year annual report for the BRET project was published in January 1983. This second-year annual report covers the progress of project operations from January 1, 1983 through December 31, 1983.

I. EXECUTIVE SUMMARY

The Botswana Renewable Energy Technology Project (BRETP) was designed as a pilot project by USAID and the Government of Botswana (GOB) in September 1980 to:

- research, develop and implement RETs which can reduce Botswana's dependence on vulnerable supplies of increasingly expensive fossil fuels; and
- introduce RETs that are inexpensive and easily reproduced in villages throughout the country.

Several features of the project's design have guided project activities:

- project activities are needs-driven and partially defined by village participation;
- as a pilot project, information, designs and strategies are being developed for both technologies and dissemination approaches; and
- the project builds upon the experience and expertise of existing institutions.

A. Major Accomplishments

Following is a brief outline of the major accomplishments of the BRET project by program focus.

Energy Needs Assessments:

- The Botswana Village Energy Survey report was published. It contained the survey results from two pilot villages, plus supplementary fuel measurements for the winter season from 45 households.
- Collaboration was established with Partnership for Productivity (PFP), Rural Industrial Officers (RIOs) and Botswana Enterprise Development Unit (BEDU) for production and marketing of metal stoves.
- General public information was distributed through Marang, the project's monthly newsletter.

Research and Development of Institutional RETs:

- BRETP, Department of Water Affairs (DWA) and Meteorological Services completed joint plans for uniform wind data collection and analysis.

- One standard fan-type windmill and monitoring equipment were installed at Sedibeng in March. Five additional boreholes were located, suitable for field testing this type of windmill.

- An engineering evaluation of the Rural Industry Innovation Center (RIIC) windmill was completed by the ARD wind consultant in May. RIIC's report was submitted in September. The evaluation concludes that the mill has potential, but is not yet near a production prototype.

- Negotiations were completed and approval given to procure a variety of photovoltaic (PV) pumping systems to total five different systems.

- Electrification of clinics at Shoshong and Mabule is complete. Lights and monitoring equipment have been installed and arrival of the refrigerator is awaited.

- PV street lights were procured for testing in three sites.

- A Memorandum of Agreement was signed between the BRET project and Solar Power Corporation for research and development of potential manufacture of low- and moderate-cost solar batch water heaters.

Development and Demonstration of Village RETs:

- Assessment of RIIC earthen stove work was completed and the implications drawn for the BRET stove extension activities.

- Two cookstove consultancies were completed resulting in a prototype metal stove, a recommended mix for earthen stoves and standard testing procedures for all stoves.

- Testing was completed on all stoves developed, resulting in the decision to proceed with production and dissemination of metal stoves. A third consultancy began in October toward this end.

- Test results on earthen stoves indicated the need for further research in materials and construction techniques, which began in November.

- A prototype retained heat cooker for three-legged cast-iron pots was designed and is currently being tested by village women in Shoshong.

- Six prototype simple batch solar water heaters were tested in laboratory and field settings. One model was selected for village dissemination.

- A training workshop was conducted in the construction of the selected solar water heater.

- Literature searches were completed on thatch insulation, solar stills, pedal-powered sorghum dehulling and solar food dryers.

- A decision was made to concentrate the project's village technology activities on cooking devices, simple solar water heaters and improved building techniques.

- Terms of reference were completed for a domestic energy-use study to be conducted in two urban areas and three major villages. ARD consultants and support staff have been identified.

- The BRET project's role in National Energy Assessments was re-established to include wind and insolation data collection and analysis, and selected studies to be identified by the Project Executive Committee (PEC).

Awareness Campaigns:

- The Awareness Plan and Implementation Guide for the BRET Project was published and provides "how-to" patterns for a range of awareness activities.

- At the village level, awareness of general energy issues was developed through discussion groups and skits performed by village players.

- Village demonstrations were conducted in:

  -- improved construction techniques--Ditshegwane Village Training Facility (VTF),
  -- portable metal stoves,
  -- earthen stoves,
  -- retained heat cookers, and
  -- simple, batch solar hot water heaters.

Passive Solar Construction:

- The solar home in Gaborone was completed in April and occupied in May. A report of winter performance was published.

- Construction of a block building and an improved rondavel were completed in Ditshegwane. These buildings comprise the VTF.

- Construction of the BTC headquarters building began in October 1983.

Training and Institution-Building:

- Four Batswana staff completed 10 to 15 weeks each of individualized training in the United States.
- Local staff training was provided in the areas of community development, planning, leadership skills, communication skills, stove testing procedures, planning awareness activities, use of windpower for water pumping and earthen stove construction.
- Village workshops were conducted in the construction and use of simple solar water heaters, retained heat cookers and earthen stoves.
- On-the-job training in installations and monitoring was provided to DWA, District Council crews and villagers during the installation of anemometers and all pumping systems.
- Madiba Electrical Brigade was trained in 12-volt, DC wiring for PV electrification.
- A plan for a national training needs assessment for RET research, development and dissemination was completed.

B. Overview

Following the arrival of a new chief of party on January 14, highlights and significant developments of the year included the growth of major technology and extension activities. In developing these activities, the BRET project has followed a sequence of planning and implementation--following concepts originally put forth in the project paper and processes developed by ARD--regarding RET selection, research and development. This began with a needs assessment, based on a combination of the National Development Plan, the Project Paper, the two village surveys, BRET project experiences and other inputs. These needs led to research and development on many rural village domestic technologies for wood conservation and institutional technologies for replacing imported fuels or providing services not yet available in rural areas. Throughout the project, there is a continuous process of training of BRETP staff along with villagers, and GOB Ministerial and District personnel related to the BRETP priority technologies. Once the technologies needed to meet identified needs exist, then the BRET project engages in an awareness campaign, at village and institutional levels, to show how the proven and available technologies can solve problems of need. The final step is actual dissemination of the technologies to villagers, districts and institutions in rural areas.

The process through these five stages has proven more complex, difficult and lengthy than anticipated in the Project Paper. Consequently, the specific outputs the Project Paper mentions are now recognized as unrealistic, according to the USAID evaluation team, December 1983. At year's end, the USAID mid-project evaluation team recommended an extension of the ARD contract and project activities until August 1985. Their recommendations included changing the nature of the outputs from numbers of technologies disseminated to identifying sound technologies and dissemination strategies for each, and issuing reports with policy and implementation recommendations to GOB staff for continuing renewable energy efforts beyond August 1985.

During 1982 and early 1983, the project experienced serious administrative difficulties due primarily to unworkable administrative relationships outlined in the Project Paper. This in turn affected the technical performance and progress at that time. In April, the Ministry of Mineral Resources and Water Affairs (MMRWA) decided to take the BRET project from the Botswana Technology Center (BTC) and administer it directly through the Planning Unit of the MMRWA. The next few months involved working out new administrative procedures and policies to match those of the Ministry. This needed change was key to resolving these administrative impasses and turning the project toward greater success.

The PEC was formed in mid 1982, but met only three times that year. During 1983, it has met monthly and proved to be an effective body for making policy, approving budget expenditures and giving program oversight. It is chaired by the Deputy Permanent Secretary (DPS) of MMRWA and has representatives from MMRWA, Ministry of Finance and Development Planning (MFDP), USAID and the BRET project.

The main body of this report includes the objective statements from the Second Annual Plan of 1983, followed by more detailed information about project accomplishments. Where necessary, 1982 activities are described parenthetically to provide background. There is a section on management and administrative issues and developments, as well as a section on the future direction of the BRET project.

PROJECT IMPLEMENTATION SCHEDULE FOR SECOND YEAR

Activity	1/83	2/83	3/83	4/83	5/83	6/83	7/83	8/83	9/83	10/83	11/83	12/83
ENERGY NEEDS ASSESSMENT:												
Complete energy needs assessment in Shoshong	X→	→	→	→	→	→	→	→	→			
Develop proposals for national energy assessment							X→	→	→	→	→	X
Develop terms of reference for urban domestic energy use survey				X→	→	→	→	→				
AWARENESS CAMPAIGNS:												
Implement campaigns in Ditshegwane & Shoshong	X→	→	→	→	→	→	→	→	→	→	→	X
Design & implement campaigns for multipliers, institutions, national audiences	X→	→	→	→	→	→	→	→	→	→	→	X
RESEARCH & DEVELOPMENT - INSTITUTIONAL RETS:												
Wind/hand pumping		X→	→	→	→	→	→	→	→	→	→	X
PV pumping	X→	→	→	→	→	→	→	→	→	→	→	X
PV refrigeration			X→	→	→	→	→	→	→	→	→	X
Solar hot water heaters	X→	→	→	→	→	→	→	→	→	→	→	X
DEVELOPMENT & DEMONSTRATION OF VILLAGE RETS:												
Stoves		X→	→	→	→	→	→	→	→	→	→	X
Retained heat cookers	X→	→	→	→	→	→	→	→	→			
Solar hot water heaters	X→	→	→	→	→	→	→	→	→	→	→	X
Thatch insulation	X→	→	→	→	→	→	→	→	→	→	→	X
Complete engineering & economic analysis of solar stills in Botswana	X→	→	→	→	→	→	→	→	→	→	→	X
Complete literature/design search & modification on pedal-powered grain dehuller; solar food dryer	X→	→	→	→	→	→	→	→	→	→	→	X
PASSIVE SOLAR CONSTRUCTION:												
Monitor performance of passive solar house in Gaborone						X→	→	→	→	→	→	X
Construct 2 VTFs & monitor performance	X→	→	→	→	→	→	→	→	→	→	→	X
Construct 2 improved rondavels, using passive principles	X→	→	→	→	→	→	→	→	→	→	→	X
TRAINING & INSTITUTION-BUILDING:												
Individualized U.S./third-country training for Batswana staff			X→	→ X		X→	→ X		X→	→	→	X
In-country staff training workshops	X→	→	→	→	→	→	→	→	→	→	→	X
Workshops for users & maintenance personnel on various RET systems		X→	→	→	→ X		X→	→	→ X		X→	→ X
National training needs assessment for RET R&D & dissemination				X→	→	→	→	→	→	→	→	X

II. ACTIVITIES AND ACCOMPLISHMENTS

A. Energy Needs Assessment

One of the 1983 objectives was to complete energy needs assessments in second and third project villages. An energy needs assessment was completed for the second project village of Shoshong, and the report is available under the title Botswana Village Energy Survey Report. Comprehensive fuel measurements were completed for the winter season in both pilot villages. Summer and fall measurements will be taken next year and a comparative report issued. A decision was made to drop the third village from the project work plan and conduct domestic energy-use surveys in major villages in conjunction with the urban survey described below.

The objectives also called for an urban, domestic energy-use survey. In the cities of Gaborone, Molepolole, Mahalapye, Serowe, Palapye and Selebi-Phikwe, the terms of reference have been completed for the study. Project staff worked closely with MMRWA officials, who approved all steps of the process. The BRET project is in close collaboration with MMRWA and the ODA group responsible for the planned rural energy assessment, to be funded by England.

BRETP activity in the area of a national energy assessment was put on hold by the PEC in December 1981, and so did not appear in the Second-Year Plan. The rationale for the delay was to ensure smooth coordination with the previously mentioned ODA study and the establishment of an Energy Unit within the Ministry. The project's collaboration with Meteorological Services in wind and solar data collection are, however, pieces of a national assessment. Additional, discrete studies will be worked out next year.

B. Awareness Campaigns

A series of strategies and tools for implementing awareness activities for village, multiplier, institutional and national audiences was developed during an ARD consultancy completed in February 1983. The activities were designed to begin at the village level and expand to the district and national levels by multipliers, institutions and mass media. Details of these plans and strategies are to be found in a report titled Awareness Plan and Implementation Guide for the BRET Project.

As part of the project's awareness campaign, a number of activities took place at the village level. An introductory awareness workshop was held in Ditshegwane (the first VTF site) in January. Planned as a general introduction to energy issues and RETs, this workshop plan included slides, a skit performed by

villagers, and demonstrations of stoves, retained heat cookers and simple solar water heaters. About 40 adults and 100 school-aged children attended. The skit was the activity most enthusiastically received. Project staff learned that skits with village players are very attractive events, that demonstrations must be scheduled at a time when more adults are able to attend, and that future village activities must include a better strategy for a higher audience turnout.

A number of lessons were learned from the first year in Ditshegwane. In summary, it seemed that villagers were disappointed in the slowness of work on the VTF and rondavel compared to the intensity of involvement in the survey. However, with intensive information sharing, planning and implementation work, the year ended with a strong commitment to and interest in the program by the Kgosi, Village Development Committee (VDC) and village residents. Project staff learned the importance of carefully pacing continuous activities. This was taken into account particularly for work at the second VTF site, Shoshong.

The official opening of the VTF was used as an awareness strategy and technology demonstration. Opening ceremonies were conducted by the District Secretary on March 2 before a large audience. Activities had been carefully planned by the Kgosi, VDC and BRETP staff, and included speeches, technology demonstrations, songs and traditional dances performed by school children, and a community feast prepared by the villagers. Technologies were demonstrated for the dignitaries present, but the event was not organized adequately to include demonstrations for villagers. Nonetheless, everyone present praised the efforts of the BRET project and of the technologies demonstrated, which included passive solar building construction of the VTF and improved rondavel, PV electrification for radio communications, mud stoves, retained heat cookers and solar water heaters.

Besides villagers and project staff, the event was attended by Kweneng District Senior Kgosi Representative, District Secretary, District Commissioner and District Development Officer, plus many villagers and representatives from MFDP, MMRWA, USAID, Peace Corps and the BTC.

In Shoshong, <u>discussion groups</u> were formed to exchange views on energy problems, conducted with the YWCA, Non-Formal Education staff, Botswana Council of Women and Village Health Committee (VHC). Group leaders used picture codes to generate discussion of problems and possible solutions to village energy needs and uses. These groups were very useful audiences for initial awareness activities in Shoshong. Picture codes were effective in stimulating discussion and were used effectively by the project's village-based staff.

In June, a solar water heater demonstration was held in Shoshong to stimulate awareness, identify participants for a user test and determine whether enough interest existed in the technology to develop a construction training workshop. Six models were demonstrated to 24 participants. Six households volunteered to participate in the week-long user test. Seven people attended a subsequent workshop.

To build relationships for future use of multiplier audiences and institutions, project staff regularly attended District Extension Team (DET) meetings in Center and Kweneng Districts. Marang, the project's English-language monthly newsletter, was initiated in April to keep DETs and other potential audiences informed of BRETP activities. Key multipliers identified during 1983 included Non-Formal Education, Rural Industrial Officers (RIOs) and the Forestry Associates of Botswana. Non-Formal Education agreed to pretest printed materials for newly literate audiences. The BRET project joined the newly formed Forestry Association of Botswana. During the RIO conference, November 29 to December 1, project staff and Rural Industrial Officers defined collaboration on metal stove production and dissemination.

The 1983 Agriculture and Trade Shows provided an opportunity to cultivate district and national audiences, to test reactions to the metal stove, and to display photographs of project activities. The Mahalapye Agriculture Trade Show in June resulted in fourteen interested stove buyers and three interested producers. Mahalapye was selected because it is the nearest major village to Shoshong.

In July, the Molepolole Agriculture and Trade Show was held. Molepolole is the Kweneng Tribal and District headquarters and major village nearest Ditshegwane. Based on the experience at the Mahalapye show, the BRET staff decided to demonstrate all of the village technologies developed to date. Great interest was shown in project activities. Several metal stoves were purchased by individuals, and a producer was identified.

At both shows, cooks were asked to use the metal stove--an excellent supplement to the display at the BRETP booth. However, the scope of the shows and the project's objectives seemed mismatched. About 120 adults and 200 children visited the booth, but its location and organization interfered with people's use of the technologies, so it was impossible to assess the degree of interest. Objectives for participation in an international show should be re-evaluated for next year. It appears that rural-based shows had better results.

The project's use of media and printed materials developed as part of its awareness campaign include Marang, BRETP's monthly newsletter, which is written in English and aimed toward potential multiplier and institutional audiences at the national and

district levels. The BRET project produced a brochure about the demonstration solar home for use during open houses. The electrification of three clinics at Lentswe le Tau, the VTF opening ceremony in Ditshegwane, and the opening of the solar house were feature articles in the Daily News. Kutlwano, a national monthly magazine, ran a feature story on the BRET project in February. Educational materials produced by project staff were distributed to Peace Corps volunteer teachers for pre-testing. A metal stove fact sheet was produced for trial testing with a market study in Old Naledi. A retained heat cooker (Wonderbox) pamphlet was produced in both English and Setswana for use in workshops.

C. Development and Demonstration of Village RETs

The purpose of the initial surveys conducted in Ditshegwane and Shoshong was to assess energy use and needs to determine which technologies to research and develop. The survey results indicated that firewood and human energy are the most widely used sources of energy in rural areas. Virtually all the domestic, transportation, agricultural and institutional needs in the village of Ditshegwane are met by these two resources.

Shortage of firewood is an acute problem in both villages, where nearly 97 percent of the households surveyed use it as their chief fuel for cooking and heating. Paraffin is used mainly for lighting. In Shoshong, a general shortage of firewood in the area was the most frequently stated concern. In Ditshegwane, it was the distance people had to walk to collect it.

Study of the survey results led the project to focus research and development efforts on wood-conserving stoves, retained heat cookers and solar water heaters for domestic village use.

1. Wood-Conserving Stoves

A few years ago, RIIC did research and development and dissemination work with earthen stoves. The success was limited, so the BRET project had to learn what it could from that experience before proceeding with a program. During January, two project extension coordinators researched the RIIC experience to learn how the stoves were introduced, what people found interesting about them, what were perceived as the advantages and disadvantages, the problems encountered, what users would recommend and how the stoves were evaluated. Project staff learned the following information:

- RIIC recommendations to develop difference designs, including a raised model, should be followed;

- demonstrations and construction workshops to teach people how to build their own stoves should be well structured;

- demonstrations of earthen stoves should include plans for protection from rain; and most important,

- structured observations and follow-up interviews with users should be conducted over time to learn how and why the stoves are actually used, and why users might alternate between cooking on open fires and stoves.

(Detailed reports about stoves, titled Wood Stove Consultancy for the BRET Project and Stove Consultancy for BRET Project, are available from the project.)

Criteria were developed for both portable metal stove and earthen stove mixes and designs to meet Botswana's needs during an ARD consultancy in early February. A second ARD consultancy during the same period focused on testing procedures for earthen as well as metal stoves. The testing procedure included laboratory water-boiling efficiency tests conducted by the researchers themselves, controlled cooking tests conducted by villagers with the supervision of researchers and, finally, kitchen performance tests, during which village women cooked usual meals without supervision. Style of earthen stoves was tested also for social acceptance comparisons. Project staff developed a record-keeping procedure to record data on all stoves built and tested.

Analysis of this experience by another ARD stove consultant currently working at the BRET project has resulted in continued research and development. With this consultant, project staff are working on:

- recording procedures for all stoves: who made it, when, where, what mix, how moist, all vital dimensions and a picture;

- the relationship between various dimensions and efficiency;

- a design using optimal dimensions;

- the resistance of various mixes to wear, erosion, chipping and cracking;

- construction techniques;

- orientation in relation to prevailing winds;

- a design using rammed earth-block base and metal top; and

- developing a demonstration and testing location at the Gaborone office.

The apparent limited potential of earthen stoves led project staff to investigate the potential of metal stoves. Information gathered during the surveys guided prototype work. The surveys showed that:

- Batswana families move around between their villages, lands and cattle posts,
- most rural families use heavy, cast-iron, three-legged pots (size 1, 2 or 3),
- most rural families have limited cash resources, and
- most have limited available metal-working skills.

The stove consultants accomplished the following tasks:

- a survey of metal-working skills, particularly sheet metal skills;
- three sheet metal, prototype model stoves were developed;
- water-boiling efficiency tests in the laboratory were completed and compared to open-fire cooking to determine what percentage of heat produced by a wood fire is transferred to the pot (the most efficient metal stove prototype proved twice as efficient as open-fire cooking under laboratory conditions);
- controlled cooking tests were completed in Ditshegwane at the VTF, where metal stoves used 40 percent less wood than open-fire cooking;
- plans were made for kitchen performance tests with unsupervised cooking at home;
- BRETP staff were trained to perform the three-stage VITA stove-testing procedure;
- all staff attended one-day training sessions--one on the theory and practice of both metal and earthen stove building and one on efficiency test procedures and how to interpret the results.

Kitchen performance tests were completed in 15 homes in Ditshegwane, showing an average 25 percent wood saving in the winter month of July. During these tests, users cooked usual meals without staff supervision. The two-week test covered one week of cooking over an open fire and one using a metal stove. At the same time each day, a project staff person would leave a

pre-weighed pile of wood at the user's home and calculate the amount used each 24-hour period for cooking, water heating, space heating, lighting and other purposes. Compared with open-fire cooking, it is estimated that a family can save between 40 and 50 percent of wood used for cooking, and 25 percent of the total wood used during cold months--more during warm months when less wood is needed for heating and light.

A sheet metal worker in Gaborone produced all BRETP test stoves from the prototype.

These results provided the evidence needed to move on to the training and dissemination stages of sheet metal stoves. The current ARD stove consultant arrived in November to review and refine the designs, materials and potential production of sheet metal stoves. Seven metal workers, potential stove-building trainees, have been found. One BEDU metal worker will be the trainer.

The project is developing a certification of producers, a logo for approved producers, a process for periodic quality control and an owners' "how to use the stove" brochure to give to purchasers. Market surveys are also underway.

2. Retained Heat Cookers (Wonderboxes)

The retained heat cooker (RHC)--also known as a hay-box or fireless cooker--is a proven technology that is used in many countries. It was developed in response to the need to conserve energy in cooking. Existing and available models were designed for flat-bottomed saucepans which are not used in Botswana. Therefore, the BRETP task was to develop an RHC to accommodate the three-legged pot used by rural Batswana.

Fortunately, most foods in Botswana are boiled, which is the best cooking method for an RHC. Once a pot reaches a boil, it is placed in an insulated container which traps the heat inside and cooks the food. The cooking time is about 25 percent longer than over a fire. The traditional cast-iron pot is ideally suited to the RHC because it absorbs heat. The RHC is also applicable to urban households and could reduce the gas or electricity used for cooking.

The literature on RHCs indicates that a 10-centimeter thickness of insulation around the pot is needed. Test data from the RET project in Lesotho indicate that thatch holds about 95 percent as much heat over an hour as the commercial Wonderbox filled with polystyrene beads. In Shoshong, BRETP staff have given demonstrations to interested villagers and are working with a group of women on design and construction of RHCs.

3. Solar Hot Water Heaters

An objective of the project was to test four prototype domestic solar water heaters for village use. Low-quality hot water is used for bathing, laundry and washing dishes. Six different prototype models of solar water heaters were developed. Tests were performed under both summer and winter conditions. Three demonstrations were conducted in Shoshong from which villagers volunteered to test the heaters at home with the supervision of project technicians. Each model was tested one week. Villagers selected a three-can, rectangular, box heater over the other models. Test results showed that this model was also the most efficient.

In September, a workshop was held in Shoshong to teach participants how to build their own water heaters and how to use them efficiently. Four heaters were built at this workshop by several women who attended. There were some construction problems resulting from their lack of familiarity with tools and building techniques. However, the heaters stood up to testing and were found to heat water within the range of 40°C to 60°C on a sunny day. A second workshop was held in December.

Those who acquired heaters were generally pleased to have something they had built themselves, particularly something that would provide free hot water (after initial capital and labor expenses to build the devices).

4. Other Technologies Researched

ARD carried out a complete literature search on the value of thatch insulation, pedal-powered sorghum dehulling machines and on solar food dryers. For a variety of reasons, it does not seem feasible or useful to pursue these technologies for Botswana at this time. For example, current food preservation practices in Botswana are fairly efficient, indicating that the testing and modification of this technology will occur only if and when there is a demand for improvement.

A complete engineering and economic analysis of solar stills was performed. RIIC is developing and testing stills. The only available water in many remote areas, particularly in the Kalahari Desert, is saline.

A preliminary report was written on the limited data resulting from tests of three types of evaporative coolers built by the project. However, this technology has been given a low priority for the BRET project.

D. Research and Development of Institutional RETs

1. Water Pumping

The Need for a National Wind Energy Assessment

There are no appropriate Botswana wind data available for estimating the potential for various wind pumping machines. Therefore, a plan was developed involving Meteorological Services, DWA and the BRET project. The plan is to:

- provide reliable wind regime data on a national scale for use by the project and other ministerial organizations;
- develop a wind regime map in relation to depths of water table to show areas of possible windmill water pumping schemes; and
- incorporate the BRET project and DWA engineering-type compilators into Meteorological Services nationwide weather reporting stations for their use after project completion.

Following the arrival of the Chief Technical Officer of Windmills for the DWA in November 1982, the BRETP and DWA staff worked together to provide spare parts (e.g., towers, boxes, batteries, PV panels, anchors, etc.) and install anemometers at sites suggested by Meteorological Services staff. Fourteen anemometers were provided by DWA using project funds, and six were purchased by the project itself for monitoring at VTFs. The national anemometery grid also includes 15 Meteorological Services sites, which are installed at 10-meter heights (see Table 1). The BRETP and MMRWA equipment sets are 32-bin compilators coupled with three-cup anemometers, powered by a 40-watt PV module and maintenance-free battery mounted inside a metal box with a sun screen. The box is welded to a 10-meter tower. Lightning-surge protectors have been installed at the BRETP/DWA sites.

The BRETP and Meteorological Services agreed to share all data, to use the Meteorological Services repair section for the BRETP/MMRWA compilators, and to train Meteorological Services personnel in the use and manipulation of data from Natural Power compilators. Data are collected in the field by police officers, teachers and health clinic nurses. Geological Survey staff in Lobatse have agreed to provide the project with a depth-to-water-table map for use in developing an overlaid map with wind regimes for all of Botswana. Data collected from the BRETP/MMRWA stations are being kept in Meteorological Services Archives.

Table 1

ANEMOMETER INSTALLATIONS AS OF DECEMBER 31, 1983*

Meteorological Services

Location	Type	Status
Francistown	a	completed
Maun	a	completed
Gaborone	a	completed
Ghanzi	b	planned
Tsane	b	planned
Tsabong	b	planned
Shakawe	b	planned
Kasane	b	planned
Mahalapye	b	planned
New Airport	a	planned
Selibe Pikwe	a	planned

Dept. of Water Affairs

Location	Type	Status
Pandamatenge	c	completed
Nata	c	completed
Gweta	c	completed
Serowe	c	completed
Motokwe	c	planned
Khakhea	c	completed
Bokspits	c	completed
Nojane	c	planned
Taktshwane	c	planned
Qangwa	c	completed
Rakops	c	completed
Khutse	c	planned
Lepepe	c	planned

plus two spares

BRET Project

Location	Type	Status
Shoshong	c	completed
Ditshegwane	c	completed
Bobonong	c	completed
Tsau	c	completed
Molepolole	c	completed
Sedibeng	c	completed

Key: a--remote reading anemometer
b--dine pressure anemometer
c--natural power, compilator giving totals of seconds at one-m/s increments from 0 to 31 m/s

*DWA and BRET project cooperated on most installations.

Multi-Blade Water Pumping Windmills

BRETP staff, in concert with DWA technicians, installed one windmill in Sedibeng, where it will serve as an initial test site for technicians to monitor multi-blade windmill performance. The PV-powered instrumentation will consist of a water flowmeter and a windspeed compilator. This will enable the technicians to determine the water output of the windmill as a function of the site wind regime, within the operating constraints of the particular borehole. Village personnel, including the village headmaster and schoolteachers, were instructed in the windmill's operation and maintenance.

Hand Water Pumping Systems

In remote areas, where diesel fuel is expensive and hard to transport, people and animals need water from boreholes and wells of moderate depths (20 to 50 meters deep). Multi-blade water pumping windmills can address this need at certain wind-rich sites. But until DWA staff have further developed the system sizing, data base and skills necessary for siting, installing, operating and maintaining windmills--or in areas where there is insufficient wind--villagers can pump water by hand.

There are many small, remote settlements and villages which need small amounts of water for human consumption from borehole depths to 60 meters. There are two likely pumps on the market which could be tested for use, performance, durability and manufacturing in Botswana. There is also a need for DWA and Council crews to learn hand pump installation and proper site set-up.

Project and DWA staff have installed a total of 17 hand pumps, eight India Mark II and nine Petro (see Table 2). At some sites, villagers were involved in decision-making and hired to install the pump. At others, only DWA crews made installations, with little discussion with local residents.

Problems encountered during the year can be divided into two types, technical and institutional. Technical difficulties arose with Swedish Petro pumps, which are not suited to Botswana's 6.5-inch boreholes. Normal mechanical problems occurred with India Mark II hand pumps which, overall, have performed best, requiring only normal replacement of cylinder leathers. Institutional difficulties occurred where DWA staff installed hand pumps on sites without proper consultation with local residents, resulting in some vandalism, lack of care and maintenance, poor reporting of faults, and other problems. In some cases, these pumps went unused because of confusion over ownership and resentment over the use of inappropriate equipment. BRETP staff have tried to solve these problems by establishing more thorough consultations at sites. Next year, all sites will have been visited.

Table 2

HAND PUMP INSTALLATIONS AS OF DECEMBER 31, 1983

Installation Date	Site	Pump Type
4/82	Moshaweng	India Mark II
8/82	Sorilatholo	India Mark II
8/82	Molengwane	India Mark II
9/82	Goo Tau	India Mark II
9/82	Malatswae	India Mark II
10/82	Mahatlhane*	Petro
10/82	Dikgonye	Petro
11/82	Kgoro/Lejwana	Petro
11/82	Molepolole	Petro
12/83	Sedibeng	Petro
4/83	Mogonye*	Petro
4/83	Malokaganye	Petro
8/82	Monwane**	India Mark II
6/82	Tlokweng	India Mark II
83	Ootse	Petro
83	Tlhareseleele	Petro
83	Mmopane	India Mark II

Key: * replaced by BTC PV system
**replaced by human traction, 10/83

Human Traction Pumps

Some isolated communities need to pump small amounts of water from a depth of 100 meters, which is too difficult for a hand pump. In the late 1940s, DWA staff designed human traction pumps for Botswana. These were installed and performed for 20 to 30 years before diesel fuel became widely used. Existing pumps need refurbishing and design improvements. This need could rejuvenate and reintroduce a technology which was developed in Botswana, and once understood by the villagers who installed, operated and maintained these pumps.

The human traction pump was first seen by project staff while looking for suitable boreholes for hand pumps. These pumps were nearly always found in a dilapidated condition, with parts missing or worn out, on dry boreholes. Discussion with local residents revealed that the pumps had been installed about 20 to 30 years ago and had only recently stopped working. Project staff decided to remove one nearly intact pump, refurbish it by strengthening the parts which wore most, and improving certain design aspects to lengthen the life of the moving parts. Project staff located a retired DWA technician who was familiar with these pumps and their locations. He has been able to lead project staff to five other human traction pumps, major pieces of which have been removed and delivered to RIIC and Momoso Engineering, both in Kanye, for refurbishing.

The pump originally refurbished by BRETP staff was reinstalled on October 24 in the village of Monwane at a depth of 67 meters. As of this writing, villagers are quite pleased with it, commenting that the pump is easier to use than the Mark II hand pump. There were problems during installation which called for some parts substitution, resulting in a reduced amount of water per stroke. However, in the end, these substitutions may make the pump easier to use at this depth. BRET is tentatively planning a training program to instruct villagers in the maintenance and operation of such pumps. Assignment of responsibility for pump upkeep, combined with the skills necessary to implement necessary maintenance, will help ensure continued long use of these pumps.

Advanced Wind Systems

If windmills are to be an option in much of Botswana, new, high-performance windmills will be needed to operate in the anticipated low-wind regime against pumping heads in the 100+-meter range common in remote areas. Standard, multi-blade fanmills will not meet these demands. Basic research and development work is needed on the coupling of advanced windmills capable of driving mono pumps commonly used throughout Botswana.

Surveys and tests are needed of the high-performance windmills available in today's market. Two such high-performance windmills are currently in the development stage in Botswana. These are being developed by RIIC in Kanye and the Windmill Technology Group Serowe (WTGS).

The RIIC windmill was located on a water supply system in the village of Mogojogojwe in December 1982. RIIC's two-month, continuous-run monitoring and testing period was completed in May. RIIC submitted an inadequate report in July. The BRET project requested additional data which were supplied in September. In the meantime, ARD's wind consultant evaluated the RIIC windmill in his final report (May 1983). The BRET project paid for the RIIC evaluation, repair and improvements to match a potential production model, and the mill was reinstalled in October. There was a minor failure and, later, a major repair.

The engineering evaluation, ARD's consultancy reports and subsequent information from RIIC allow the BRET project to conclude that the mill has potential. Pumping performance of the second prototype is comparable to currently available commercial machines. However, certain design and mechanical weaknesses must be further investigated to determine its reliability and durability. These considerations are absolutely crucial to the long-term success of any pumping device. The RIIC windmill does, however, have the following advantages: it is made locally; it is designed to drive Mono pumps (which are on 80 percent of the boreholes in Botswana); it is designed to run at relatively low windspeeds. Additional data are being provided by the RIIC researchers, upon receipt of which a more extensive review of the research and development process and the subsequent applicability of the windmill can be made.

WTGS began developing a variable-speed, rotary-output windmill for mono pumps at the same time as RIIC. A WTGS prototype was ready for testing and modification in July. The project ordered monitoring equipment to assist in testing. Two additional prototype windmills for field monitoring have been approved and ordered.

The foreign-made, high-performance reciprocating pump windmills--Kijito and Wind Baron--have been developed and monitored over the past six years and have been in production for a couple of years. More than 100 of each have been sold. Available performance data are very encouraging. The BRET project has initiated procurement, which has been approved and will be completed when appropriate boreholes for these four windmills have been located.

In summary, the BRET project is undertaking an extensive comparative testing program which will monitor the performance of two Kenyan Kijito machines, two U.S.-made Wind Barons, the RIIC and WTGS Botswana-made machines, and several conventional

machines. The monitoring program will instrument 15 windmills to gather data on wind regimes, pump strokes (and, indirectly, rotor RPM) and the volume of water pumped during the experiment. Long-term accumulated data will allow researchers to determine the usefulness of the different manufacturers' machines to the wind resource available in Botswana. The data will be gathered on a monthly basis and analyzed by BRETP staff. Short-term studies will generate pump curves of water output as a function of instantaneous windspeed. These curves, along with data being gathered in the anemometry program, will allow much more precise matching of a particular machine's capabilities and costs with a specific site. Data from the compilators will effectively add 15 sites to the ongoing wind assessment study anemometry program.

Photovoltaic Pumping

Insolation in Botswana varies from approximately 7.4 kWh per square meter per day in December to 4.5 kWh in May. This is more than adequate to make PV-powered pumps economically effective under a wide variety of water demands. Tentative economic analyses have been made (Wind Energy Technology for the BRET Project: A Consultancy Report, available from the BRET project) which compare the life-cycle costs of water pumping with several currently available windmills and PV pumping systems. Preliminary results are favorable. There is a need to demonstrate to staff that PV systems can provide adequate and reliable water supplies in remote areas and reduce Botswana's dependence on imported diesel fuels.

The choice of pump/motor type is a function of both the depth from the storage site to the water level (static head), and the volume of water required. The BRET project plans to evaluate a number of different types of pumps (submersible, surface-mounted motors for driving mono pumps, deep well jack pumps) in boreholes for which they are best suited. Since pump/motor types vary in efficiency, the monitoring of these units is very crucial to the determination of their technical and economic suitability for Botswana.

Early on, the BTC insisted on pursuing the less efficient but more commonly encountered mono pump options. The BRET project could not get a clear decision, but by year's end, negotiations had taken place with MMRWA and DWA to release funds for purchasing a variety of PV pumping systems. These were:

- two medium-depth (30-meter) DC submersible systems,
- one DC mono (deep borehole) system,
- one DC jack pump (deep borehole) system, and
- one DC submersible system for a shallow (15-meter) hand-dug well.

Besides the controversy over the choice of systems, borehole location was a major problem, as with windmills. Borehole specifications, such as depth, yield, and so forth, must be determined before proper system sizing can begin. DWA engineers seemed reluctant to consider PV power as a viable alternative to diesel pumps. The DWA position of not using vital boreholes for "experiments," or for systems of unknown reliability, has prevented the project from acquiring boreholes and, therefore, delayed the sizing and ordering of systems. The project is currently initiating meetings to resolve this with DWA personnel arranged by MMRWA, and some headway is being made.

2. PV Electrification

The GOB is committed to providing health facilities for all Batswana, as stated in the National Development Plan. Through the MMRWA, health centers have been provided with electricity and running water. Clinics, however, being smaller and designed for a smaller population, have not yet been electrified, and the cost of installing conventional diesel engines would be very high.

Clinics are located for serving a population range of 4,000 to 8,000 people within a radius of 15 kilometers. They may, however, serve 12,000 or more people because of the distance between clinics and other facilities. Reliable electrical supplies are needed to store vaccines and medications, as well as to keep maternity wards open at night. Currently, gas and paraffin-powered refrigerators are used, but are unreliable for maintaining consistently low temperatures. Therefore, the present system must be replaced with reliable alternatives which do not rely on imported fuels and, hence, comply with the National Development Plan's effort to reduce dependence on imported fuels.

Three clinics were selected for electrification--the Lentswe le Tau Health Clinic, the Shoshong Health Clinic and the Mabule Health Clinic. They had the following characteristics in common:

- peak power requirements of about 1,000 watts,
- no plans for upgrading their status to Health Center and, therefore, probably no increase in their power needs,
- application for solar water heaters,
- need for maternity wards and other facilities at night,
- radio-phones, and
- possible dissemination to the private sector (bottle store, private home and other businesses).

The Lentswe le Tau Health Clinic was electrified by PV in June 1982. The system is comprised of nine PV panels and four batteries--the main components for a system--which power four fluorescent lamps, a high-intensity lamp, refrigerator and torch battery rechargers. The lamps are used mainly in the maternity ward, delivery room and consulting/treatment rooms. The refrigerator performed well for the first six months and maintained a temperature within the required range of 3°C to 10°C. Monitoring ceased in December 1982 when the refrigerator unit broke down. Since then, the project has been trying to get it repaired locally, but without success so far. The lights have been working well.

The Shoshong Health Clinic was the second to be electrified, and installation of the system was completed in September 1983. It is a larger clinic than the Lentswe le Tau clinic, so nine fluorescents were installed with six batteries for storage. A high-intensity lamp and rechargeable torch are being provided.

The third clinic, Mabule, was electrified in October. It is about the same size as the one in Shoshong, with seven fluorescents and six batteries for storage. The refrigerator is on order.

Electric lights have improved the working conditions of the nursing staff in all three clinics. They are now able to handle emergencies and deliveries at night more effectively. Villagers are aware of PV systems and have shown interest in finding personal uses for them, especially in Shoshong, where there is a more prosperous population.

Clinic staff record daily refrigerator temperatures on data sheets provided by the project. For example, during the operational period of the refrigerator at the Lentswe le Tau clinic, the temperature range was between 3°C and 10°C.

MMWRA proposed a demonstration project involving three units of street lights for nighttime social activities and security. MMRWA, the Department of Electrical Engineering and the BRET project developed a plan for locating one unit in Mabule and two around Gaborone for monitoring. The Department of Electrical Engineering will install the units in Gaborone; the BRET project will install the units in Mabule. The units arrived near the end of the year.

Another new item, requested by the Ministry of Local Government and Lands (MLGL), was for schoolroom lights. Each village could use at least one lighted room at night for teacher preparation, student studying, and community meetings. MLGL wanted funds for installing one PV system in each village for lighting a schoolroom for a few hours each evening. The BRET project and MLGL developed a plan for four demonstration villages, including monitoring, as the data could be helpful to

the Ministry in seeking funds for a broader program at a later date. The project received PEC approval in December.

3. Solar Water Heating

There are a number of solar water heaters available on the market and many upper-income houses have them installed. One system was purchased from Solar Power, Inc., and installed in one of the project houses in Kanye. However, neither comparative testing data nor evaluations are available. No testing has been done to date, but discussions have been held with faculty members in the Physics Department of the University of Botswana who have indicated interest in proposing a testing program. Other priorities have stood in the way of evaluating the need for simple batch-type passive solar water heaters in schools and clinics. However, a double, 210-liter batch water heater was developed in Kanye for institutional use. The prototype was not entirely successful: The water volume to glazing surface area ratio was too large, so that the temperature of the water supplied by the heater was not high enough. Future research and development work on this may be proposed by RIIC.

There are no solar water heater systems produced in Botswana. Most of the imported systems have expensive, electric geyser back-up systems. BRETP staff believe there is a definite market for locally produced systems. During the year, the project worked with Solar Power, Inc., to develop a research and development proposal for the potential manufacture of low- and moderate-cost batch systems. The project is funding a portion of the research and development cost in a Memorandum of Agreement signed by the project and Solar Power at the end of the year.

E. Passive Solar Construction

Current design and construction practices in Botswana, at all income levels, result in houses that are cold in winter and hot in summer. Electricity is sometimes used for heating and cooling; coal is also used for heating. To show that the use of electricity or coal can be reduced without sacrificing indoor comfort, the BRET project designed and built an energy-conserving passive solar house. The house drew upon a standard Botswana Housing Corporation (BHC) design, and added certain passive features (orientation, window placement, roof insulation, etc.) to achieve high interior comfort levels during both heating and cooling seasons. Construction was completed in April. The chief of party and his family moved in in May.

Microcomputer monitoring equipment was installed in June. This equipment measures the thermal performance of the house, which will allow for economic comparisons with conventional housing designs, as well as provide data for improved, lower cost

designs for future residential buildings. The official opening of the new dwelling was held soon after and was attended by the president, five ministers, many senior government officials, and representatives from many GOB departments and parastatals. The Ministers of MMRWA, the U.S. ambassador, the project's chief of party and the ARD solar engineering consultant gave speeches. Project staff took visitors on educational tours of the house.

Monitoring has continued through the year. A complete report of findings for the winter months, Winter Performance of the Solar House - Shakawe/EC, is available through the project. Another monitoring system is being installed in a standard BHC Shakawe Type II house for data comparison. In general, the BRETP passive solar house has performed up to its design expectations during both heating and cooling seasons. Its high thermal mass kept indoor temperature fluctuations to less than 4°C in the winter, with average indoor temperatures around 22°C. In the cooling-season data reviewed thus far, maximum indoor temperatures have consistently remained about nine degrees below maximum outdoor temperatures without the use of any energy-consuming air conditioners.

In Ditshegwane, construction was completed on the block structure and improved rondavel at the VTF site. Detailed construction drawings were completed, and building began in October on the joint BRETP/BTC office building.

F. Training and Institution-Building

Training activities have occurred in four major areas:

- U.S. and third-country training for BRETP staff,
- in-country training for BRETP staff,
- training for users of village RETs, and
- training for users of institutional RETs.

The process of developing and organizing project activities provided much of the information about staff training needs. Needs assessments for staff were conducted informally throughout the first year. Formal, structured staff training needs assessments occurred early in the second year, and ongoing assessments have taken place as project activities reveal new areas of need. A plan was developed for surveying training needed for RETs in GOB ministries, departments and parastatals to develop in- and out-of-country programs.

The project provided training for staff and other key participants in energy planning and policy; technology assessment; technology transfer; installation and maintenance of PV systems for pumping, refrigeration and lighting; installation and maintenance of wind-pumping systems; solar instrumentation; and passive solar design and construction.

1. U.S. and Third-Country Training for BRETP Staff

In-country staff training was supplemented by training programs in other African countries and the United States. To gain further information and experience in RET development, the Village Technologist, Project Coordinator and Extension Coordinator attended various seminars in Lusaka, Zimbabwe.

Ten- to fifteen-week training courses in the United States were attended by BRETP Solar and Wind Technicians, the Project Coordinator and the Village Technologist. At ARD's home office in Burlington, Vermont, and at Brace Research Institute (BRI) of McGill University in Quebec, the trainees received a two-week introductory overview of the state of the art of RETs and their development. Discussion topics at ARD included the history of renewable energy, resource groups, and appropriate vs. inappropriate use of RETs. At BRI, training sessions covered introductions to BRI's approach to appropriate technology and development, to BRI microprocessors and data logging systems, and to the BRI windmill program. Training sessions at both ARD and BRI included numerous site visits to see RETs in use.

After the introductory overview, the trainees split up to pursue topics specific to their individual BRETP jobs and stated training needs. The Wind and Solar Technicians attended a week-long course on basic PV technology at ARCO Solar, Inc., in Los Angeles, California. From there, they traveled to Blue Sky Water Supply in Billings, Montana, for a week of instruction in water pumping systems. Home Energy Workshop in Fort Collins, Colorado, was their next stop for three days of training in the construction of batch solar water heaters for residential use, and PV panel component assembly.

The Wind and Solar Technicians also attended a short workshop at New Mexico Solar Energy Institute in Las Cruces, New Mexico, on the testing and development of both batch and thermo-syphon, flat-plate domestic water heaters. At New Mexico State University in Las Cruces, the trainees' two-week course focused on comprehensive windmill theory and applications. From there, they went on to Wind Baron Corporation in Phoenix, Arizona, for five days. They attended classes, assembled a windmill on a sub tower, and practiced troubleshooting their installation.

Finally, the Wind and Solar Technicians returned to Vermont for a two-week course at the School for International Training (SIT) in Brattleboro, which focused on project management. Their U.S. training program ended with a two-day wrap-up and evaluation session back at ARD in Burlington.

Meanwhile, the Project Coordinator joined the Technicians at the ARCO Solar and Blue Sky training sessions, then entered a six-week course in energy management at the Brookhaven National Laboratory in Upton, New York, followed by the wrap-up at ARD.

For the Village Technologist, training consisted mainly of a U.S. Department of Agriculture (USDA) course in Washington, DC, on the initiation and management of integrated rural development programs. At the end of the USDA course, she joined the Technicians at SIT for a brief workshop in project management. The Village Technologist also attended an intensive training course at the University of Vermont on the use of the BRETP Apple IIe microcomputer. After completing this course, she was able to instruct other project staff in the use of their various computer software packages.

Upon completion of the training program, each trainee was given an evaluation questionnaire. Trainees stated unanimously that the training contributed "very much" to their overall goal of improving their technical capabilities in the development and management of specific RETs and associated extension activities. The concensus was that their training successfully built on previous on-the-job, in-country training, and was relevant both to their individual skill development needs, as well as to the needs and priorities of Botswana.

2. In-Country Training for BRETP Staff

In-country staff training has centered on how to conduct awareness campaigns; design and implement village training workshops; select, assess and monitor technologies and do economic analyses of them.

In February, a one-week workshop was conducted by the Project Coordinators and Extension Supervisors for all staff to:

- define and examine the project as a community development effort;
- review extension and training techniques and identify project applications;
- develop a basic understanding of project technologies;
- develop a basic understanding of interorganizational relationships;
- develop procedures for monitoring and evaluating technical, socioeconomic and overall project activities;
- plan future project activities; and
- develop leadership and team skills.

This workshop met most of its objectives and succeeded best in a re-examination of the BRETP community-development approach and the implications of this approach for the project, in cross

training between the technical and extension staff leading to integrated staff planning. Other training needs were identified at this time and had to do mainly with clarifying and strengthening the role of the Village Facilitator and the blend of technical and extension aspects of the project.

In June, a facilitator training workshop was held. There were three staff facilitators on board by this time. The purposes of the workshop were to:

- improve the general understanding of project activities and how they fulfill project goals;
- understand how the community-development approach is applied to project activities;
- learn how to organize and plan work and set goals and objectives;
- understand staff roles and interrelationships;
- develop evaluation and monitoring skills; and
- participate more fully in planning and developing project activities.

Besides providing an orientation and role clarification for the facilitators, this workshop reinforced planning skills and the integration of project activities. It also helped project staff to identify additional training needs, such as more experience with village RETs and more practice conducting demonstrations.

In November, the Institute of Development Management (IDM) staff trained BRETP facilitators in communications skills. As facilitators are crucial to a successful village dissemination process, their general leadership training and extension skills, plus their familiarity with RETs and RET demonstrations, needed improvement. IDM staff held a one-week workshop for facilitators and village-level extension workers from other ministries to develop skills in interpersonal communications, information gathering, listening, working with groups and interviewing.

From February to March, the ARD metal stove consultant provided three project staff with on-the-job training in how to use VITA's international stove testing procedures and data analysis and how to interpret the results. (This led to including testing methodologies and scientific inquiry methods in the U.S. training for technical staff.) Training also included earthen stove mix, construction and design techniques.

Between December 1982 and February, a public awareness consultant conducted day-long training sessions with all project staff centered on identification of multiplier and institutional

audiences and selection of suitable tools for reaching them. This training will be reinforced as actual implementation of the project's awareness campaign plans get underway.

The ARD windmill consultant conducted a half-day seminar for DWA trainees and project staff on the use of wind power for pumping. A day-and-a-half workshop on windmill design and operation was also held.

3. RET User Training

The BRET project has been conducting training workshops for users and responsible maintenance personnel in wind- and hand-pumping systems, PV electrification, solar instrumentation, anemometry, solar water heaters, fuel-efficient cooking devices and energy-efficient housing design.

At the village level, RET training focused on:

- a solar water heater workshop in Shoshong;
- an earthen stove building workshop in Ditshegwane, in conjunction with a stove testing program;
- a development plan for stove training in the Old Naledi low-cost housing project;
- a presentation at the VHC Seminar, Mahalapye Rural Training Center, on how village RETs can help meet village health goals;
- an RHC construction workshop in Shoshong; and
- an analysis of potential for training in metal stoves with RIIC officers and PFP clients.

At the institutional level, training focused on:

- windmill systems, with on-the-job training and skills assessment completed during the installation of a pump at Sedibeng, and a half-day overview of wind use for water pumping given to DWA trainees by an ARD wind consultant;
- PV electrification, with training for the Madiba Electrical brigade in 12-volt DC wiring during installations at Lentswe le Tau, Shoshong and Mabule Health Clinics;
- human-traction pumps, with orientation on the repair, modification and manufacture of the pumps with RIIC and Momosa Engineering, a small business in Kanye;

- anemometry, with orientations for school teachers and policemen at installations throughout Botswana to train them in taking readings from the compilator (teachers involve their science classes in this activity); and

- passive solar construction, with meetings held at the house to introduce passive solar concepts, explain design features and further explore the applicability of this technology to Botswana.

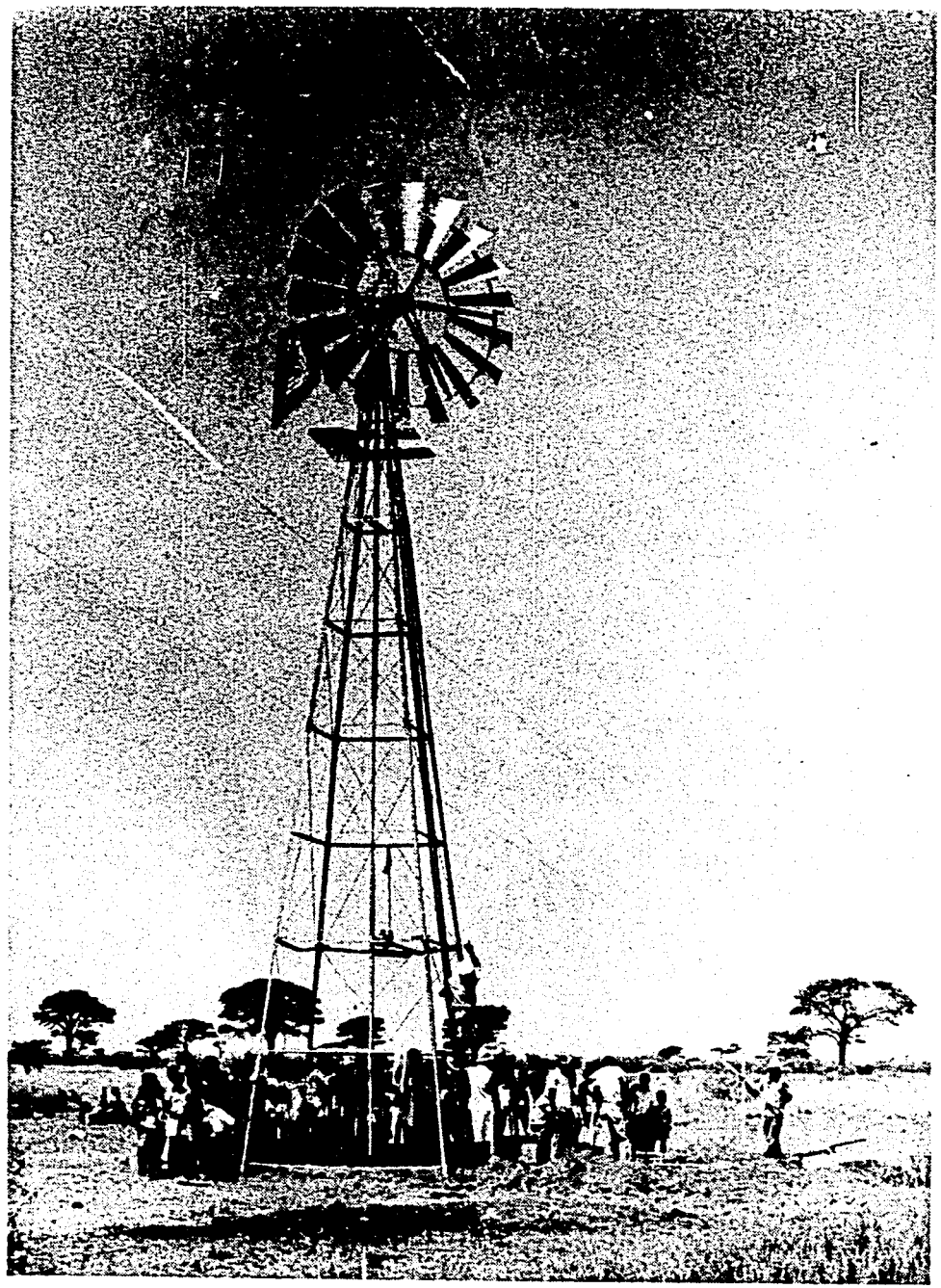
Village Facilitator, Kegakgametse Bathobasele, weights firewood for controlled cooking tests in Ditshegwane Village.

2

Controlled cooking-test procedures are reviewed at the Village Training Facility (VTF) at Ditshegwane. The VTF is a low-cost demonstration of passive solar design.

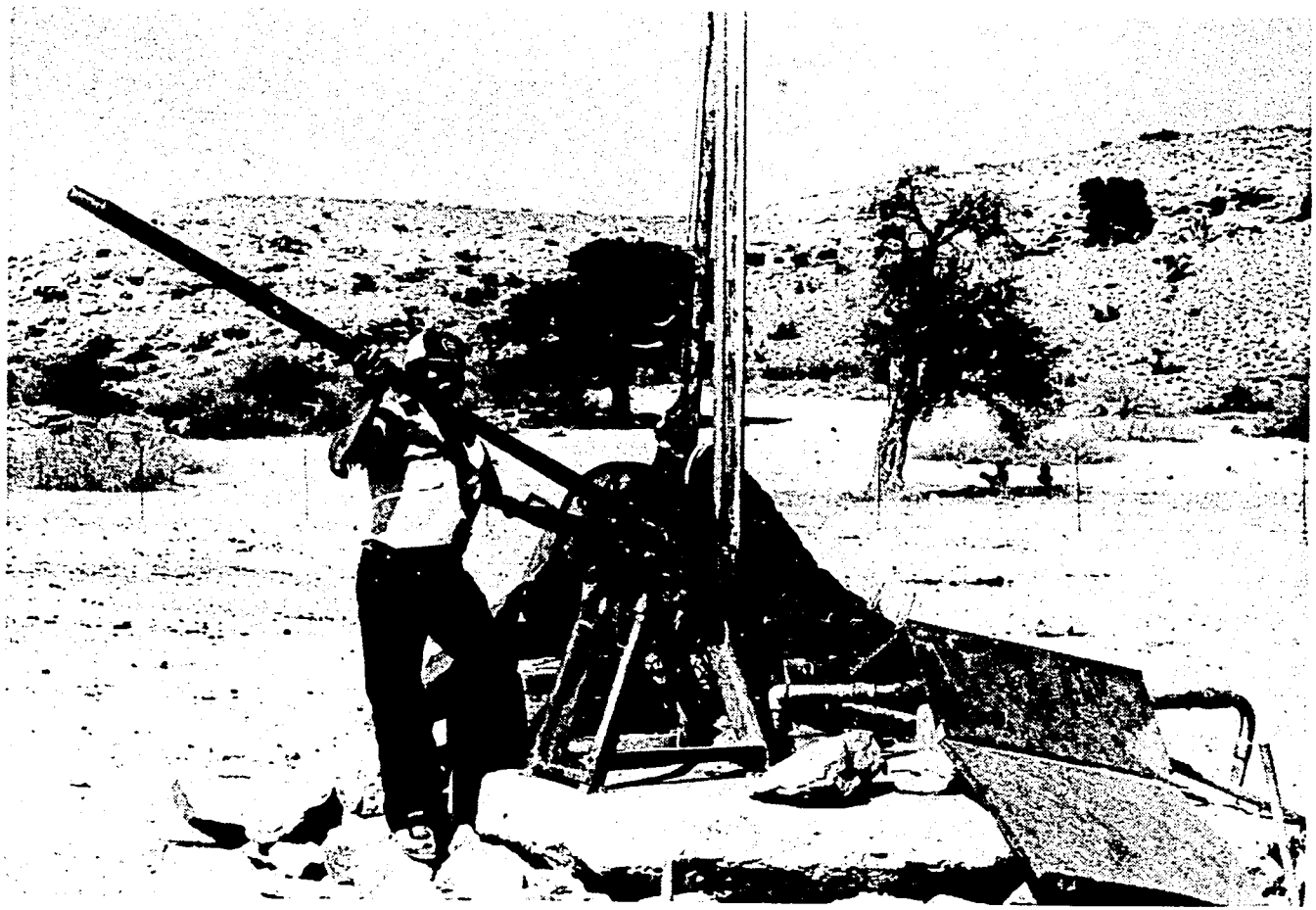
A Gaborone tinsmith produces a BRET
prototype stove for controlled cooking tests.

C



School teachers at Sedibeng brought students to the windmill installation to learn how this technology would be tested as a method for pumping water.

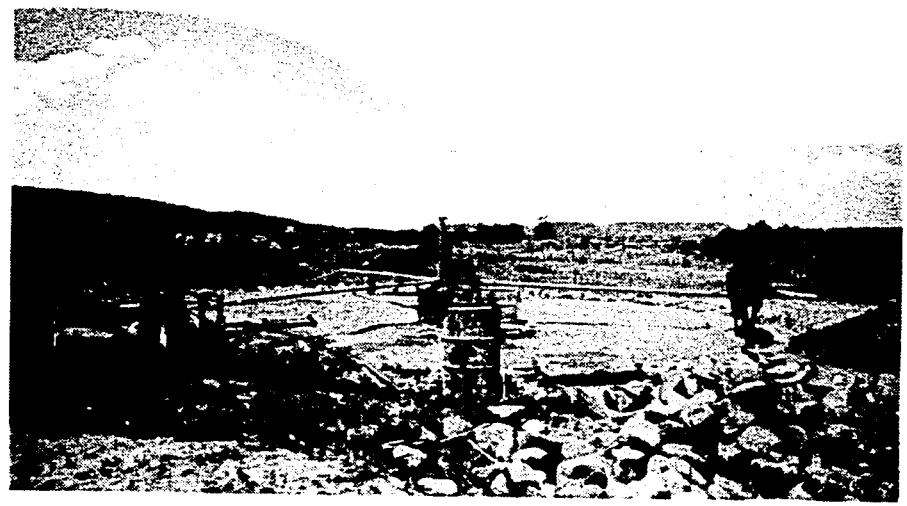
Minister of Mineral Resources and Water Affairs, Dr. G. M. Chiepe, and Mr. Theodore Maino, U. S. Ambassador to Botswana, at the opening of the solar house.



Modise Motshoge, BRET Wind/Water Technician.

BRET project staff operating the human traction pump

One of the project's handpumps in operation



Animal traction pump built by RIIC

III. SUMMARY OF PROJECT MANAGEMENT AND ADMINISTRATION

Monitoring and evaluation record keeping and reports have been systematized. Staff meetings are held for a day or two at the end of each month for planning and scheduling purposes. Efforts have been made to involved technology, extension and management staff in planning specific activities and technology installations. Relating the community-development approach to all planning has been a major goal. Some staff meetings are used for training.

The most significant management development of the year was the separation of the BRET project from the BTC, making the project directly responsible to the MMRWA. This process ran from April to June. Liaison meetings between the two entities were held once every two weeks until they ceased to be useful. Following the separation, the BRETP worked out a sound planning and reporting procedure with the Ministry concerning finances, personnel, technology research and development, and general program planning, implementation and monitoring.

The PEC meets monthly for review of the BRETP program and to approve future planning and expenditures. This has been an effective policy-making and monitoring forum. The membership includes representatives from MMRWA, MFDP, USAID and the BRET project. It is chaired by the Deputy Permanent Secretary of the MMRWA.

All annual and quarterly reports and plans have been submitted on time. The format has changed over the course of the year for more concise, objective-oriented reports related to budget line items and expenditures. Written quarterly reports and revisions are submitted regularly and include planned activities, accomplishments, current status, and budget and expenditure summary.

A new chief of party arrived in January to assume leadership of the project. Three facilitator positions were filled for Ditshegwane, Shoshong and Gaborone, and the new position of a technical research assistant was approved and filled. The extension coordinator and trainer resigned in September for personal reasons. Recruitment for a coordinator continues, and a trainer has been selected. The current project coordinator (counterpart) has been designated to join MMRWA's Energy Unit and recruitment of a replacement has begun.

The administrative assistant, whose job included bookkeeping, secretarial and general administrative tasks, resigned in September and has been replaced by a bookkeeper, typist and general administrator. The Peace Corps volunteer village technologist resigned in June. Three other volunteers finished their two years of service at the end of 1983, and the Peace Corps wind/water technician has extended his service for one year.

All Batswana staff are performing very well. One of the major strengths of the project, as seen by the expatriate staff, is the quality of the Batswana staff, the in-service training they are receiving and the competencies they are developing on the job. This training is due in large part to the work of the Peace Corps volunteers who have developed strong relationships with Batswana nationals.

ARD provided short-term technical assistance totaling 13 person-months in 1983, for a total of 20.8 person-months to date. ARD's contract calls for a total of 25 person-months of short-term technical assistance. Clearly, over the total life of the project, ARD will be providing more months of short-term technical assistance without additional expense to USAID or the GOB.

Consultant Services During the Second Year

Consultant	Person-Months	Focus of Consultancy
Ms. E. Morgan	1.6	public education and awareness strategies
Ms. M. Thomas	.6	earthen stove work evaluation and plan
Mr. G. Burkett	.6	metal stove building plans
Mr. H. Geller	2.2	metal stove design and testing
Mr. R. Smith	2.6	windmill technology assessment and installation
Mr. R. McGowan	1.6	installation of and staff training in use of monitoring data logger
Mr. E. Brunet	2.4	stove fabrication and manufacture
Mr. G. Burrill	1.4	technology assessment

IV. ISSUES FOR THE FUTURE

The direction and focus of the project have been more clearly defined this year. The mid-term project evaluation helped the BRETP staff refine its direction and focus, as did the new administrative arrangement. Major issues to be addressed and resolved next year are:

- filling key extension staff positions;
- finalizing the selection of boreholes for field testing pumping systems;
- determining the need for and scope of woodlot/on-farm/ multi-use forestry study, with USAID/REDSO and the Ministry of Agriculture;
- identifying other energy assessments needed by the GOB;
- developing and implementing a year-long, field-testing scheme for the following pumping systems:

  -- 15 Mark II and Petro pumps,
  -- 8 human traction pumps,
  -- 8 standard, fan-type windmills,
  -- 8 high-performance Wind Baron, Kijito, RIIC and WTGS windmills, and
  -- 4 photovoltaic systems;

- developing and implementing a comparative study of the above and RIIC animal traction pumps, RIIC bio-gas pump, and diesel and grid electrical pumping;
- installing PV electrification units at three more clinics;
- completing the monitoring and evaluation of PV electrification at three clinics, two street lights in rural settings and four rural classrooms;
- accepting revised project outputs; and
- implementing recommendations of the mid-term evaluation, including improved research methodology, more clearly defined extension strategies and an early decision on contract extension.

Assuming that the project log frame revisions, recommended by the evaluation team, are accepted and the project is extended, significant progress is expected in all activity areas. Specific objectives for 1984 include:

- collecting seasonal fuel measurements in two pilot villages and completing a comparative analysis;
- completing domestic energy-use data collection and analysis for three major villages and two urban areas;
- analyzing wind data gathered over a one-year period to determine available wind energy in Botswana;
- collecting solar radiation data for major climatic regions in Botswana;
- monitoring research and development work of local entrepreneurs in development of low- and medium-cost solar water heaters;
- developing a testing plan for first production units of locally manufactored residential solar water heaters and existing imported units on BHC houses;
- developing and testing simple batch low-cost solar water heaters for rural institutional use;
- monitoring performance and comparing all project buildings with standard buildings;
- completing construction of Shoshong VTF;
- conducting passive solar building design workshops for architects, planners, builders and construction supervisors;
- developing and testing diffusion strategies for earthen stoves, sheet metal stoves, retained heat cookers, small batch solar water heaters and earthen bread ovens;
- completing materials test, developing and testing earthen stove prototype using best materials;
- designing and testing RHCs for three-legged pots;
- collecting field use and attitude data from users of all rural domestic technologies;
- completing and publishing institutional assessment and guide for two pilot villages and districts;
- completing installation of all demonstration units in revised Project Paper outputs;
- developing outreach extension strategies for each technology system;

- conducting training needs and skills assessment to learn what additional training is needed to carry out project activities and guide the GOB on future training needs;
- conducting training in selected RET systems, based on above and field experience; and
- providing more staff training, locally, on the job, or in a third country.

Appendix A

LOGICAL FRAMEWORK

LOGICAL FRAMEWORK FOR THE BOTSWANA RENEWABLE ENERGY TECHNOLOGY PROJECT

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
GOAL: To improve the economic welfare of the lower to medium income Batswana by increasing their spending and earning power through introduction of RETs derived from locally available resources which are cheap and abundant; and to minimize dependence on imported petro fuels and to decrease the growing demand for fuelwood through RETs and awareness of conservation needs.	1. Diminishing rate of increase in lower income Batswana family expenditures due to decrease in increasing family expenditures on petro fuel products for family needs. Expenditures _____yrs. Before RET Expenditures _____yrs. After RET diminishing rate of increase 2. Decrease in the increasing volume of petrol fuels imported into Botswana. Quantity Import _____yrs. Before RET Quantity Import _____yrs. After RET increasing at decreasing rate 3. Decrease in the increasing amount of time spent on firewood collection by family members.	1. Income data gathered intitial Needs Assessment Survey and follow-up income data generated during internal evaluation of village process. 2. Import/Export data-CSU 3. Family time allocation data collection during initial Needs Assessment Survey and follow-up data generated during project internal evaluation of village process.	1. That RET will make a visible impact on family expenditures. 2. That RETs are viable substitutes to petro fuel technology. 3. That selected RETs do decrease consumption of wood practiced under traditional conditions in Botswana.
PROJECT PURPOSE: To develop village-level awareness for energy use and conservation; to introduce village RETs which are easily reproduced and cheap; and to research and develop and put into use RETs which are more suitable for institutions and/or entrepreneurs and more geared toward reducing dependence on fossil fuels.	Conditions that will inidcate purpose has been achieved: End-of-project status: 1. Villagers in two pilot sites aware of fuelwood around villages and able to relate this factor to inefficient use of fuelwood and aware of rural domestic technologies and other energy sources such as sun and wind.	1. Interviews with villagers during project internal evaluation of village process.	

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
	2. Installation of village-level RETs at private individual or village group expense at two pilot sites.	2. Number of village RETs installed in pilot sites.	
	3. Installation of other RETs in three districts.	3. Number of institutional RETs installed.	
	4. Process for the dissemination of RETs described for Botswana.	4. Records of experience or project final report and recommended strategy.	
	5. Reports and recommendations for which RETs can be used where, for what cost or comparative unit C/B ratio.	5. Quality of final reports.	
OUTPUTS:			
1. Energy Needs Assessment Data Collection.	1. Data collection and reports: a. Energy use and attitudes in two small villages, three major villages, and two urban areas.	1a. Survey data, analysis reports.	1a. No data on village energy use in Botswana.
	b. Wind data and wind power analysis from 49 anemometer sites around the country.	1b. Data, analysis, report.	
	c. Solar radiation for major climatic regions in Botswana.	1c. Data, analysis, report.	
	d. Selected national energy assessments to support GOB master plan.		
2. Village Awareness Campaign.	2. Village awareness campaign in two pilot sites.	2. Notes and work plan.	
3. Training in Rural Domestic, Other RETs.	3. Training: a. Training planned and implemented for relevant villagers, DWA and Council technicians at each pump installation site (all pumps).	3a. BRET records: training plan, participant rosters.	3. That there are no trained personnel in RETs in most areas of Botswana.

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
	3. b. Train entrepreneurs in the production and sale of village RETs, i.e., metal stoves, simple solar water heaters, retained heat cookers, mud ovens.		
	c. Train relevant village and district extension staff in application, use and construction of rural domestic RETs in addition to how to conduct extension and training programs.		
	d. Train relevant health personnel in use and operation of PV equipment in clinics.	d. BRET training records: training plan and participant records.	
	e. Train Brigades and relevant district maintenance and installation crews in each PV clinic electrification site.		
	f. Train construction crews and Brigades in siting, orientation, and installation of solar water heaters.		
	g. Train architects, planners, engineers and construction workers in design and construction of passive solar buildings.		
	h. Train three manufacturers in the production of human traction pumps and low-cost solar water heaters.		

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
4. Construct Six Model Solar Passive Cooled and Heated Buildings.	4a. House complete 4/83. b. Office building complete 6/84. c. Rural housing, two rondavels and two block-construction houses in pilot villages, 3/83, 84.	4. AID records.	4. Passive solar building design is the wave of the future in Botswana in that it is more economic and feasible.
5. Installation of Rural Domestic RETs.	5a. User reactions and acceptance of rural RETs introduced in pilot villages. b. Dissemination strategies for each rural domestic RET.	5. BRET records and final report. BRET records, final report, recommendations.	5. RETs are acceptable.
6. R&D on Rural Pumping RETs.	6a. 47 systems installed. Socioeconomic and technical data on each pumping system, and comparisons among pumping systems: 15 hand pumps 8 human traction pumps 16 windmills 6 PV pumps 2 animal traction pumps	6. BRET reports.	6. That water pumping systems are a high priority for rural villages and instructions.
7. Passive Solar Building Design.	1a. House and office designs completed 12/81. b. Monitor performance of six solar buildings. c. Monitor for comparison six similar standard buildings. d. Assist in design of school building. e. Comparison report, economic issues, with recommendations.	7b. BRET records. d. BRET records. e. BRET records.	

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
8. PV Electrification.	8a. Install refrigeration and lighting systems at six rural clinics/posts for field testing and monitoring. Comparative data on two types of refrigerators. b. Install three demonstration street lights. c. Install four demonstation school rooms.	8. BRET records.	
9. Batswana capacity to manage and implement ongoing extension, training and research after the RET project.	9. Counterpart skills that would enable them to be placed in comparable key positions in existing institutions.	9. Assessment of skill requirements of relevant institutions; GOB/institutional acceptance of skills and qualifications.	9. That Batswana need to be trained in RET R&D, installation, extension, and management.
INPUTS:			
1. Village Needs Assessment Survey.	1a. Designed by sociologist, RET specialist and short-term consultants. b. Supervised by sociologist/extension person and Peace Corps coordinator. c. Implemented by RET facilitators. d. Analyzed by extension support and training unit with short-term consultants.		
2. Village Awareness Campaign.	2a. Designed by sociologist, RET specialist/trainer, short-term consultants and non-formal education unit, MOE. b. Supervised by sociologist/extension person and Peace Corps coordinator. c. Implemented by RET facilitators with support of headquarters staff.		

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
3. Training.	3a. RIIC-short courses in institutional RET production and maintenance in technical detail and some village domestic RET training for facilitators and entrepreneurs; approximately 25 courses during three years, for two weeks.		
a. Short-term U.S. training (40 person-months).			
b. RIIC.	b. VTF-one to two weeks' awareness/construction courses in village domestic RETs; approximately eight courses within three VTFs.		
(1) Contact GOB for government trainees.	c. Training materials and equipment.		
(2) Contact parastatals and NGOs for production and maintenance.	(1) Purchase of training vehicle by GOB.		
(3) Train technical RET project trainers.	(2) Purchase of audio-visual/media training equipment.		
c. VTF.	(3) Compiling training material by training unit with non-formal education and short-term consultants.		
(1) Contact kgotla for village trainees.			
(2) Contact village group organizations for village trainees.			
4. Training Materials and Equipment.			
a. Long-term technical assistance - six person-months.	4a. Two long-term technicians (six person-years).		
	(1) Renewable energy specialist.		
	(2) Sociogist/extension specialist.		
b. Short-term technical assistance - 25 person-months.	b. 25 person-months of short-term consultancies. Five months will be used to carry out a National Energy Assessment Study.		
5. Research and Development on RETs.	5a. Wind/hand/advanced pumping system.		
	b. PV pumping system.		
	c. RET health center equipment.		
	d. Woodlot management.		

Narrative Summary	Objectively Verifiable Indicators	Means of Verification	Important Assumptions
	5e. Pedal-power sorghum dehuller.		
	f. Ethanol fuel feasibility.		
6. Construction.	6. Some design and construction of buildings at five sites:		
	a. RIIC - four structures.		
	b. BTC - one-third of building.		
	c. VTF - one structure at each of the three sites.		
7. Others.	7. Others.		

Appendix B

SUMMARY OF PROJECT ACTIVITIES BY DISTRICT

This summary describes the range of activities in each of the BRET project's two pilot districts and a look at all the potential RET applications that district planners might consider.

Kweneng District was the first choice owing to its proximity to Gaborone. Central Distict, Botswana's largest, was chosen as the second pilot district. Because a goal of the project is to build institutional awareness and capacity for dissemination and management of RETs, it was felt that district-level involvement in the project from the start was crucial. Villages chosen for pilot activities were in close cooperation with district officials. The BRETP recommended criteria, and districts recommended three to five villages that met the criteria. Once all parties agreed to the choices, the following steps were taken:

- preliminary kgotla meetings to explain the overall BRET project and introduce the notion of a village energy survey;
- selection of villagers to help with data collection;
- implementation of the survey;
- analysis of the results;
- sharing of the results with villagers;
- selection and development of prototype technologies to meet village needs, specifically cooking devices, solar water heaters and energy-efficient building design;
- involvement of villagers in the testing and subsequent redesign of technologies; and
- dissemination of technologies.

A. Activities in Kweneng District

Kweneng has been the major activity area for the project at both the village and institutional levels. At the village level, activities are centered around Ditshegwane, covering the construction of the VTF, and development and testing of cooking devices and solar water heaters. The institutional RET activities have covered water pumping, PV electrification and anemometry.

Post-survey activities in Ditshegwane have included construction of two buildings at a site allocated for project activities by the VDC. The passive solar design buildings enable temperature regulations during summer and winter. Officially opened in March, the buildings are the focal points for BRET project village activities. A latrine was also built, using an Environmental Sanitation Protection Project design. A radio was installed in the Village Training Facility to enable communication between the village facilitator and the Gaborone office.

Most of the project's development and testing work has been done in Ditshegwane on six models of earthen stoves and on a portable metal stove. Water-boiling tests have been completed on all stoves for preliminary efficiency indications. Six village women have been involved in controlled cooking tests on both mud and metal stoves, and 15 households participated in kitchen performance tests on the metal stove, which is very popular as "it saves wood," "takes less time to cook," and "is portable." Mud stoves were built in five households for future kitchen performance tests, but further development of an earthen stove model is needed.

DWA and the BRETP installed hand pumps in Moshaweng, Sorilatholo, Molengwane, Mahatlhane, Molepolole and Monwane. One is planned for installation near Mmopane. A human traction pump was installed in Monwane in October to replace a manufactured hand pump.

A PV system was installed at the Lentswe le Tau Health Clinic in August 1982 to provide electricity for a maternity room and a refrigerator. The PV panels were removed in February so the clinic could be renovated. There are plans to wire the rest of the clinic for lights in the rooms and to reinstall the refrigerator as soon as it has been repaired.

The project installed anemometers in Ditshegwane and Molepolole. DWA and the BRETP have plans to jointly install anemometers in Motokwe and Lephephe.

The BRET project facilitator is a member of the VDC and attends meetings regularly. She keeps the VDC briefed on project activities, does secretarial work for the committee and looks for additional ways the project and the VDC can work together. A project representative regularly attends DET meetings. The BRETP participated in the Molepolole Agriculture and Trade Show.

B. Activities in Central District

Project activities in the Central District began in late 1982 with an energy-use survey. At the village level, activities are centered around Shoshong, including the development of the VTF site, the demonstration and development of cooking devices,

and simple solar water heaters. Institutional RETs have included windmill pumping, anemometry and PV electrification.

Land allocated to the project for construction of a Village Training Facility included two rondavels in fairly good condition. One of these will be retrofitted. Construction of a square building and a new rondavel will incorporate passive solar design features. A latrine and shelter for demonstrating cooking devices were constructed. Plans for the square building are on the drafting table. A community work day was held to engage the community and to generally prepare the site for construction.

Discussion groups were held with BCW, YWCA, NFE and VHC to determine priority energy problems and to agree on what RETs to introduce.

The VHC and the Shoshong clinic staff showed great interest in the earthen stove and asked that a demonstration unit be built at the clinic. The stove is now scheduled for testing and will be used to conduct cooking and nutrition classes. Members of the VHC have built a simple retained heat cooker for use with traditional three-legged pots and are now developing recommended cooking times for various foods.

Five households participated in kitchen performance tests on the metal stove. Three of the five purchased the stove.

Simple solar water heaters are in use by four households following a workshop on construction and user tests.

With DWA, project staff installed hand pumps in Goo Tau and Malatswae.

A PV pumping system has been sized and ordered for an irrigation scheme for the Mahalapye Development Trust.

Project staff are assessing the feasibility of rebuilding an existing windmill in Shoshong and are in the process of deciding whether to rebuild it or install another system for testing. The Wind Technology Group in Serowe developed a windmill for local manufacture. The project is supporting the development and testing of that system and buying two units for installation.

The project installed anemometers in Nata, Gweta, Bobonong, Serowe, Rakops and Shoshong to supplement existing anemometers belonging to DWA and Meteorological Services.

A PV system for lighting and refrigeration was installed in the Shoshong Clinic. The lighting system is fully functional, and project staff are awaiting delivery of the refrigerator. The Madiba Electrical Brigade in Mahalapye has been trained to do the wiring for the 12-volt DC systems at Lentswe le Tau, Shoshong and Mabule.

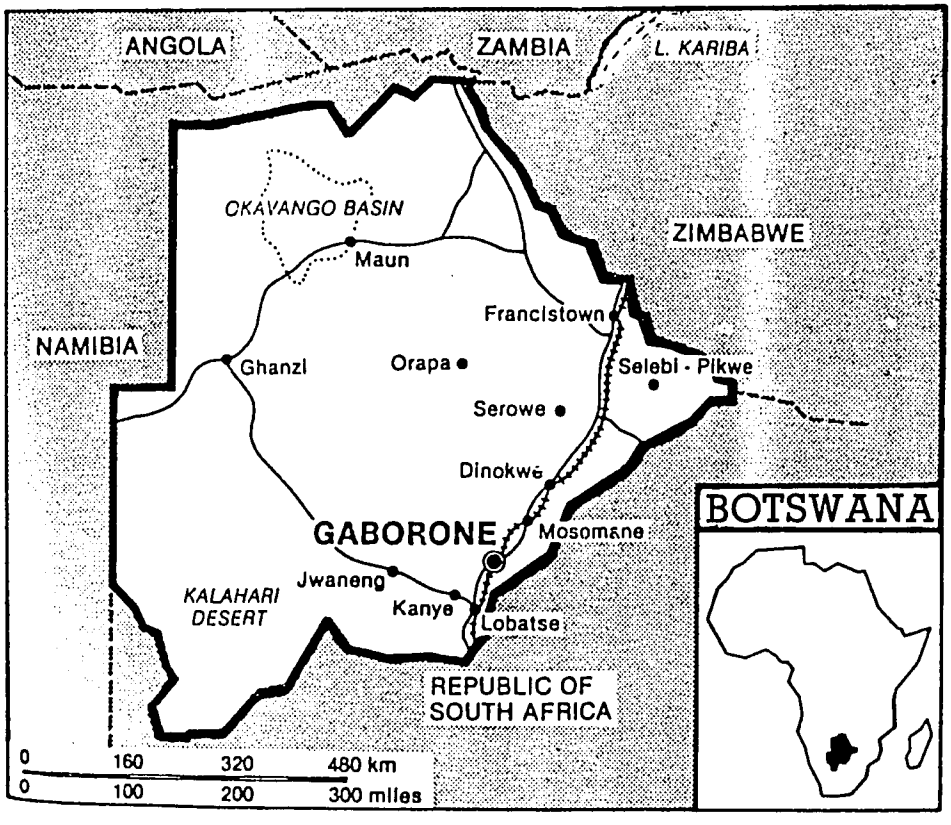
The project facilitator is a member of the VDC and attends their meetings regularly. She keeps them briefed on project activities and seeks out new ways that they and the project can work together. She also meets with the VHC and local organized groups.

Project staff participated regularly in the Central District Extension Team meetings, attended a district seminar for VHC workers in June, and presented ways in which RETs could help VHCs in meeting their concerns--specifically, the high incidence of home accidents, such as burns from open fires and paraffin poisoning.

The BRET project participated in the Mahalapye Agricultural Show.

Appendix C

MAP OF BOTSWANA



Appendix D

ACRONYMS

ARD	Associates in Rural Development, Inc.
BEDU	Botswana Enterprise Development Unit
BHC	Botswana Housing Corporation
BRETP	Botswana Renewable Energy Technology Project
BRI	Brace Research Institute
BTC	Botswana Technology Center
DET	District Extension Team
DPS	Deputy Permanent Secretary
DWA	Department of Water Affairs
GOB	Government of Botswana
IDM	Institute of Development Management
MFDP	Ministry of Finance and Development Planning
MLGL	Ministry of Local Government and Lands
MMRWA	Ministry of Mineral Resources and Water Affairs
PEC	Project Executive Committee
PFP	Partnership for Productivity
PV	photovoltaic
RET	renewable energy technology
RHC	retained heat cooker
RIIC	Rural Industry Innovation Center
RIO	Rural Industrial Officer
USAID	U.S. Agency for International Development
USDA	U.S. Department of Agriculture
VDC	Village Development Committee
VHC	Village Health Committee
VTF	Village Training Facility
WTGS	Windmill Technology Group Serowe

Appendix E

PUBLICATIONS TO DATE

Health Center Electrification in Botswana: Preliminary Findings

Design of Demonstration Passive Solar Buildings

Technology Development for the BRET Project: A Consultancy Report

Stove Consultancy for BRET Project

Awareness Plan and Implementation Guide for the BRET Project

Wind Energy Technology for the BRET Project: A Consultancy Report

Prototype Metal and Mud Wood-Burning Cook Stoves for Botswana

Wood Stove Consultancy for the BRET Project

Building Public Awareness in Botswana: A Consultancy Report

Botswana Village Energy Survey Report

Monitoring of Passive Solar Buildings in Botswana

Preliminary Evaluation Report on RIIC Small-Scale Desalination Efforts

Winter Performance of the Solar House - Shakawe E/C

Overview of Staff Training: Botswana RET Project

Metal stove factsheet

Retained heat cooker pamphlet

Solar home brochure

Marang - BRETP monthly newsletters

BRETP Quarterly Reports

Botswana RET Project First-Year Annual Report

Botswana RET Project Second-Year Annual Report