PN-AAX-905

DEVELOPMENT AND DISSEMINATION OF RETAINED HEAT COOKERS

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Under AID contract number 633-0209-C-00-1024-00.

Date: August 30, 1985

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ACRONYMS

AID	U.S. Agency for International Development
ARD	Associates in Rural Development, Inc.
BEDU	Botswana Enterprise Development Unit
BHC	Botswana Housing Corporation
BRET	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
NDP-5	Fifth National Development Plan
PFP	Partnership for Productivity
PEC	Project Executive Committee
PV	photovoltaic
RET	renewable energy technology
RHC	retained heat cooker
RIIC	Rural Industry Innovation Center
RIO	Rural Industrial Officer
SDA	Seventh Day Adventists
TESIE	technical, economic, sociocultural, institutional or energy (assessment model)
USDA	U.S. Department of Agriculture
VDC	Village Development Committee
VHC	Village Health Committee
VTF	Village Training Facility
WTGS	Windmill Technology Group Serowe
YWCA	Young Women's Christian Association

PREFACE

The Botswana Renewable Energy Technology (BRET) project (number 633-0209) is jointly funded by the government of Botswana and U. S. Agency for International Development (AID). Technical assistance and project management are being provided by Associates in Rural Development, Inc. (ARD) of Burlington, Vermont, under AID contract number 633-0209-C-00-1024-00. This report describes a portion of the work undertaken by Ms. Judith A. Oki, ARD's extension support supervisor for the BRET project.

I. EXECUTIVE SUMMARY

The retained heat cooker (RHC) is one of three cooking technologies selected by the Botswana Renewable Energy Technology (BRET) project for development and pilot diffusion in response to the need for reducing consumption of firewood for rural domestic activities.

An RHC works as follows. A pot of food is brought to a boil on a fire or stove and simmered for a specified period of time, depending on the food and taste/consistency preference. At the end of that time, the pot is quickly placed in a well-insulated container where it continues cooking, using the heat retained in the pot, food and water, and protected by the insulation.

RHCs were popular in Europe during the First and Second World Wars in response to fuel shortages. A commercial model called the "Wonderbox" has been demonstrated in Gaborone and Serowe, so it is not totally unknown in Botswana.

The BRET project's work focused on determining cooking times for local foods; determining how the RHC could be used with traditional three-legged pots; quantifying the fuel savings when used with firewood, paraffin (kerosene) and gas; and most important, determining its acceptability in rural areas and methods for its dissemination.

This report describes the activities undertaken during exploration of the above issues. The activities included working with a community group to determine cooking times for local foods and to adapt the RHC for three-legged pots; conducting controlled cooking tests with local women using open fire, the BRET metal stove, paraffin and gas cookers; conducting demonstrations, offering free trial periods of use, teaching extension workers to make and use RHCs; following up to determine use patterns over a six-month period; and financial and economic analyses of the device.

The BRET project found that:

- the RHC can be used to cook the most frequently used food items in Botswana and will save 40 to 60 percent of the fuel used;

- the RHC is economically attractive if it is used 50 percent of the time, the opportunity cost of extra cooking time is valued at zero, the cost of firewood is valued at three thebe per kilogram, and there is no real increase in the real price of firewood (there is considerable debate about the opportunity cost of the extra cooking time--valuing it at zero

is a compromise between the view that it is a cost and the view that the time the food is unattended is in fact a benefit--see page 17 for discussion);

- frequency of use and the skill and confidence required to use an RHC are education issues, and dissemination approaches have been designed to successfully address those issues;

- the RHC can be made by its owner or purchased--BRET project experience indicates that users who make their own RHCs have more confidence with and satisfaction from the device;

- RHC users engage in other domestic activities while food is unattended in the RHC;

- demonstrations are effective in generating interest, but guided practice is necessary to develop skill and confidence in RHC use (providing guided practice will increase training/dissemination costs); and

- the potential market for the RHC includes every household that does not currently have one, as the RHC can be used with every cooking device.

The BRET project recommends a modest program of training and extension, to be carried out by trained members of three targeted extension cadres. An additional recommendation is that further investigation of commercial potential be undertaken and, if warranted, substantial training be done with existing commercial sewing groups to encourage them to take up production and marketing of the RHC.

II. INTRODUCTION

The retained heat cooker is one of three cooking technologies selected by the BRET project for development and pilot diffusion in response to the need for reducing consumption of firewood for rural domestic activities. The purposes of this report are to:

- summarize the current status of the technology by describing the activities undertaken as well as conclusions drawn by the BRET project's village technologists and extension staff; and

- provide a useful starting point for continued dissemination activities.

A brief overview of the project and the RHC are provided below to establish a context for this report.

Overview of the BRET Project

The BRET project was designed as a pilot project by the Government of Botswana's (GOB) Ministry of Mineral Resources and Water Affairs (MMRWA) and the U.S. Agency for International Development (AID). The project paper was completed in September 1980. In August 1981, Associates in Rural Development, Inc. (ARD), of the United States, signed a contract to provide technical assistance and project management, which began in October 1981 and ended in September 1985.

ARD fielded two long-term staff and numerous short-term consultants. During the project's first year, most of the 15 Batswana counterparts and administrative personnel were hired. Five U.S. Peace Corps volunteers (PCVs) worked with the BRET project in 1982 and 1983, while two served during the third year.

The project was designed to further the energy policy goals of Botswana's Fifth National Development Plan (NDP-5). As defined in the project paper, the purposes of the BRET project were to:

- introduce village renewable energy technologies (RETs) that are easily reproduced and inexpensive; and

- research, develop and put into use RETs which can reduce Botswana's dependence on vulnerable supplies of increasingly expensive fossil fuels.

To fulfill these purposes, the following "needs-driven" technology development and dissemination process was used:

- needs and resource assessments,
- technology identification, matching and selection,
- prototype development and testing,
- comprehensive field testing and pilot education, and
- widespread dissemination or transfer to the public domain.

Community involvement, training and technology adaptation occur at several steps in the process. At each stage, data were collected and analyses made of the technical, economic, sociocultural, institutional and energy (TESIE) issues related to each technology. This information was used to make decisions about whether to continue with the next step in the process, make adaptations or abandon the particular technology.

As a pilot project, the BRET project set out to build its activities and analyze its experiences in ways that would provide TESIE analyses of the selected technologies. These analyses are presented as conclusions in this report. A detailed description of the technology development process and the TESIE assessment model can be found in Appendix A of this report.

The work of the BRET project began with the selection of two pilot villages for research on domestic RETs--Ditshegwane in the Kweneng District, with a population of 820 according to the 1981 census, and Shoshong (population of 4,600) in the Central District. To perform the in-depth domestic needs assessment, an energy use and attitude survey was conducted during 1982 in these two pilot villages, and in three towns and three major villages during 1984. It was found that the availability and conservation of firewood for cooking, lighting and heating was the major energy need in Botswana.

To address this need, research and development work was carried out on a variety of stoves and cooking devices. As of the end of the pilot project, both sheet metal stoves and retained heat cookers had been found to be effective and economical and are ready for widespread dissemination.

The BRET project supported solar desalination work carried out by the Rural Industries Innovation Centre (RIIC) in Kanye, as well as the development of two commerical batch solar water heaters by an entrepreneur in Gaborone. In addition, the project undertook research and development on several simple batch solar water heating systems.

With regard to community or "institutional" RETs, as they were referred to in the project paper, both the BRET project and other studies determined that the following energy-related needs were of high priority:

- water pumping systems,
- lighting and vaccine refrigeration for health clinics in rural areas, and
- the thermal comfort of buildings in summer and winter.

Thus, as called for in the project paper, the BRET project carried out research, development and field testing of hand, solar and wind pumps (both standard and advanced windmills). During the course of the project, the pumping program was expanded in cooperation with RIIC to include human and animal traction and biogas pumps. Also, due to the clear need for better water pumping information, a comparative pumping assessment was added to the project's activities. At the end of the pilot project, 45 pumping systems of various types had been installed, including a monitoring and data collection program for the pump comparison effort.

Photovoltaic electrification systems were installed, along with accompanying monitoring equipment, at three rural health centers for lights and refrigeration, and four elementary schoolrooms for lighting. However, because both wind and solar resource data for Botswana are sparse, a program for wind and solar radiation data collection and assessment was developed.

The BRET project carried out a variety of activities related to energy efficiency in building design and increasing the thermal comfort of buildings. Research, development, construction and monitoring were completed on eight houses and three small office buildings. A number of training activities on energy-efficient building design were undertaken, and two solar design workbooks and a thermal performance analysis procedure were also developed.

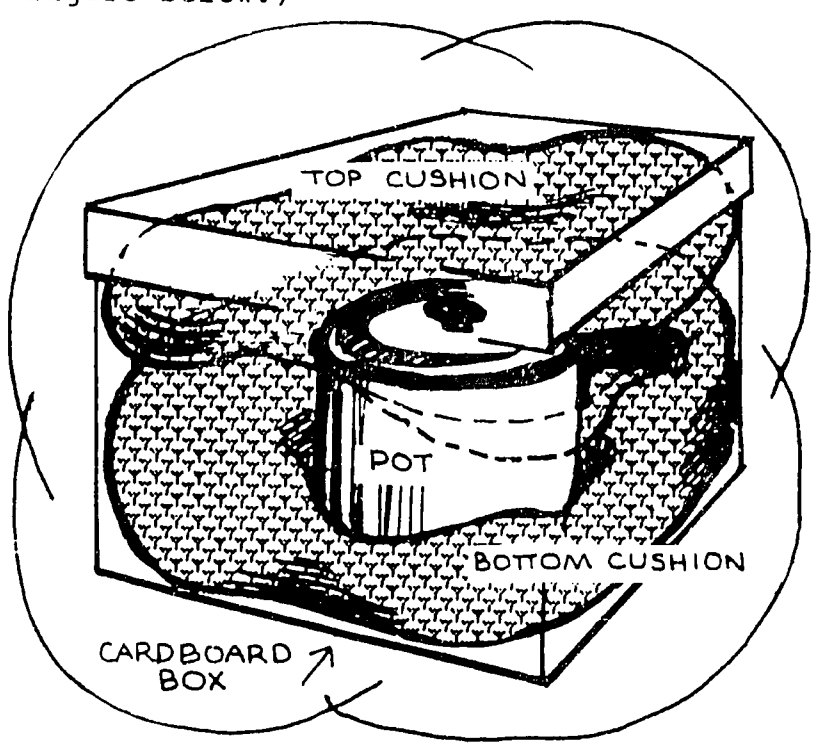
In connection with all of the activities mentioned here, extensive training activities were conducted for BRET project staff (some in the United States) as well as a large number of extension workers, technicians, engineers and architects working for various government and parastatal agencies, and rural people in the districts where the BRET project was active.

Separate reports on each of the technologies were prepared. A complete list of BRET project reports is given in Appendix B.

Description and Background of the RHC

A retained heat cooker, sometimes called a "haybox" or "fireless cooker," works by keeping a container of food hot enough to continue cooking after a short initial period on a stove or open fire. During the initial time on the stove or open fire, the food is brought to a boil and simmered for some time. It is then removed to the RHC where it continues to cook, using heat that is stored or retained in the pot and its contents. Water does not evaporate from the pot when it is in the RHC; therefore, less water is required to cook with an RHC. Water quantity is an important factor in retained heat cooking. Too little water results in "hard" or undercooked food, and too much results in food that is too soft or overcooked. The range of satisfactory results is highly subjective. Thus, given a set of good starting guidelines, cooks must be encouraged to vary water quantity to suit their own tastes.

An RHC can be made by stuffing any container with enough good insulating material (e.g., polystyrene beads, thatch, newspaper, etc.) to surround the pot on all sides with a thickness of at least 10 centimeters. A commercial model called a "Wonderbox" has been developed in South Africa and is available locally. It is a cardboard box, with two specially designed cushions stuffed with polystyrene beads. The bottom cushion has a fitted "nest" for the pot, and the top cushion is used to cover it. Simpler versions include a box filled with hay, into which a covered pot is inserted and then covered with a cushion, and several thicknesses of blanket or sleeping bag wrapped around a pot, which can be left as is or put into a container, basket or box. (See figure below.)



The fireless cooker was popular in Europe during the First and Second World Wars in response to fuel shortages, and is described in "Mrs. Curtis' Cookbook," published in the United States in 1909 (Fireless Cookery, H. Kirschner, Madrona Press, 1981).

The Seventh Day Adventist (SDA) mission to Botswana, in cooperation with Mrs. Harry Oppenheimer, conducted demonstrations of the commercial Wonderbox in Botswana, primarily in Gaborone. The SDA mission has sold more than 500 Wonderboxes, mostly to middle- and upper-middle-class urban dwellers. Dr. Gaositwe Chiepe, former Minister of Mineral Resources and Water Affairs, has supported demonstrations of the Wonderbox in her constituency, Serowe, and although it was in limited use in rural villages at the beginning of the BRET project, it was not entirely unknown. When the BRET project began, the Wonderbox was sold for P8.00 (US$10). Another commercial model called "Cook-O-Magic" was being sold for P42.00.

RIIC developed an RHC using fabricated sheet metal for the container and foam rubber for insulation. Pilot diffusion of that model in the Kgalagadi District has yielded similar results to those obtained by the BRET project. The fabricated sheet metal container costs approximately P20 and is out of the affordable range for many rural villagers, but does provide a durability lacking in the other models.

In December 1982, the Lesotho Renewable Energy Technology Project conducted RHC performance tests using a variety of insulating materials. The commercial Wonderbox and a homemade version of it performed best in the laboratory. Chaff-stuffed pillows were next, and the cardboard box and mud box stuffed with hay and covered with hay-stuffed pillows followed. There was, however, little difference among them. After one hour, there was only a temperature difference of two or three degrees Celsius. The detailed test results are available in "Report on Retained Heat Cooker Tests," by M. Khoboko and M. Lenono, Lesotho RET Project, Ministry of Cooperatives and Rural Development, Maseru, Lesotho. These results established the technical viability of a homemade model. What remained was to determine how local foods and local cooking utensils could be used with RHCs, how RHCs could be disseminated in rural areas, and quantification of fuel savings.

The remainder of this report describes the BRET project's activities in development of the RHC for use with local foods and utensils and in dissemination to rural households. The project built on the experience of others to develop local applications for the RHC. The focus was on determining cooking times for local foods; adapting the RHC for traditional, three-legged, cast-iron pots; quantifying fuel savings for RHCs used with firewood, paraffin and gas; and most important, determining the

RHC's acceptability in rural areas and methods for its dissemination. The activities described were carried out by the BRET project's village technologists and extension staff and are presented in the sequence of the technology development and dissemination process described above.

III. DEVELOPMENT AND DISSEMINATION

A. Needs and Resource Assessments

Cooking is the primary end use of firewood, although it is difficult to assign specific proportions of wood consumption among cooking, heating water, space heating and lighting. It is also difficult to determine in concrete terms the social aspect of the open fire. Nonetheless, cooking devices have the potential to reduce firewood consumption for cooking and, therefore, the overall consumption of firewood.

Survey results indicated that 80 percent of the households in Shoshong use three-legged, cast-iron pots ranging from size 1 (three liters) to size 3 (seven liters). In Ditshegwane, a single food--maize or sorghum porridge--was cooked once a day. About 26 percent of the time in Shoshong, and less frequently in Ditshegwane, meat and/or vegetables were cooked to accompany the porridge, requiring two pots for cooking. The average cooking time for porridge is about 45 minutes, requiring constant stirring over high heat to avoid sticking, burning or an uneven, lumpy texture. Meat is generally boiled for 20 to 45 minutes, sometimes longer, depending on the type and tenderness of the meat. Vegetables are cooked for a relatively long time, sometimes with oil added, until they are very soft. Cabbage, for example, is generally cooked for some 45 minutes. Samp, whole kernels of a hardy maize, is cooked two to four times a month, requiring five or six hours of cooking time. The cooking fire is also used to simultaneously heat water.

These were the practical design parameters that were considered for development of cooking devices for rural Botswana. Of course, it was also expected that any device would be more efficient than an open fire.

The survey further indicated that financial and material resources within the village and at the individual-household level were limited. The selection of responsive RETs needed to consider these factors as well as local cooking practices.

B. Technology Identification, Matching and Selection

In looking at the wide range of available cooking technologies, it was necessary to select those that would meet the economic, social and cultural criteria established for the selection of village-level RETs. The RHC was selected because it is well suited for local cooking, in which most foods are brought to a boil quickly and continue simmering for fairly long periods of time (45 to 75 minutes). The traditional cast-iron cooking pots absorb and store a great deal of heat from the fire or stove

and are good pots for use with an RHC. In addition, the RHC can be made by its owner from recycled or "free" materials (e.g., grass, newspaper, etc.) or purchased at a relatively low price.

In Ditshegwane, khadi, a fermented berry drink, is wrapped in old blankets to retain the heat and thereby encourage fermentation. Therefore, the notion of retained heat cooking was not entirely new in that limited segment of the population.

C. Prototype Development and Testing

The BRET project did not develop any original prototypes as such, but modified and tested known models for local application. The performance of various designs had been documented. In "Fireless Cookery," Heidi Kirschner states that what is critical is having at least four inches or 10 centimeters of insulation on all sides of the pot. The Lesotho RET project's results with insulation materials similar to those available in Botswana supported Kirschner's claim.

The BRET project gave specific consideration to:

- cooking times for local foods;
- models suited for three-legged pots;
- fuel savings when RHCs are used with open fire, the BRET metal stove, paraffin and gas cookers; and
- user reactions.

Adapting the RHC for Local Foods and Pots

The BRET project combined these two considerations in a highly participatory way--by working with women in Shoshong to develop a three-legged pot model and determine cooking times for local foods.

The project's full-time staff person in Shoshong solicited participation in an RHC activity from the Botswana Council of Women (BCW), the Young Women's Christian Association (YWCA) and the Village Health Committee (VHC). Members of those organizations were invited to attend a demonstration of the RHC. At the end of the demonstration, participants were asked to cooperate in making RHCs that could accommodate a three-legged pot and in testing cooking times. A number of women volunteered to meet weekly to construct and then test the devices.

Participants were asked to bring materials from their homes for containers, cushions and insulation. While the women were

able to come up with containers and fabric for cushions, they were hard pressed to come up with suitable insulation material. The drought had affected the availability of thatching grass; it takes a long time to save enough feathers to stuff RHC cushions; newspapers and sawdust are not readily available in smaller villages; and there is a cultural norm against using clothing or blankets for cooking. One woman did bring and cut up old clothes for insulation, and another carefully saved feathers over an eight- to 10-week period.

The women met weekly for six weeks. Five units were made, and cooking times were determined for rice, mealie rice, porridge, samp and beans. The cooking times were similar for all types of insulation used--thatch, old clothes and feathers. These formed the basis for a recipe book (see Appendix C). After experimenting with different fabrics and cushion shapes, it was decided that three-legged pots could best be used in a box filled with straw and covered with a cushion.

In addition to achieving the initial goal of adapting the RHC for local use, the group of women involved in the testing became confident RHC users and a core of resource people for subsequent demonstrations in the village.

Two technical issues emerged from this activity. The first was availability of suitable insulation for a homemade RHC. The second was concern about combustion of cushion fabric and insulation. To address the first issue, the BRET project sought materials that could be collected in bulk and used for construction workshops. RIIC's carpentry shop donated sawdust, and Tiro Ya Diatla (a craft industry) provided discarded wool. Both were subsequently used to make RHCs, but there is some concern that the wool will mat inside the cushions after some time. Over time, it is likely that the wool insulation will need replacing. The exact time needs to be determined through follow-up of long-term users.

To investigate the second concern, combustion of cushion fabric and insulation, the BRET project village technologist performed a simple test with the sawdust and wool. Uncovered nests of the insulation material were made, and a three-legged pot filled with water was heated to a rolling boil on an open fire and then placed in the nest, i.e., directly against the insulating material. After an hour, the insulation was checked and no combustion had occurred. The synthetic fabrics predominant in Botswana might melt, but it is not likely that combustion would occur. RHC users need to be advised to use a strong cotton fabric for the cushions.

The BRET project concluded that while RHCs could be made with recycled materials, insulation would prove to be a problem for most villagers. In locations where there are carpentry

workshops, sawdust provides a possible solution. To use three-legged pots with an RHC requires a container filled with thatch, sawdust or a similar nonsynthetic material, and a cushion to cover the pot once it is placed in the container.

Satisfied that the RHC could be used for local foods and pots, and having determined cooking times for local foods, the BRET project moved on to determine fuel savings.

Determining Fuel Savings

A series of tests was conducted to determine and compare savings achieved with the RHC and a range of cooking fuels and devices. The tests compared an open fire, a BRET metal stove, a gas cooker and a paraffin stove. The results quantified the expectation that using an RHC provided great savings of any cooking fuel. These tests, conducted by women from Mogoditshane, a village near Gaborone, had the additional advantage of comparing the results of actual users, not laboratory technicians. Each woman was assigned one of the stove types (i.e., open fire, metal stove, paraffin stove or gas stove) and performed eight tests on the device alone, and eight with the RHC. The results are shown in Table 1.

Table 1

Average Fuel Savings when RHC Is Used in Combination with Selected Stoves

	Average Savings for Foods with:	
Stove Type	Short Cooking Time*	Long Cooking Time**
Open fire	40.0%	44.0%
BRET metal stove	51.4%	50.0%
Gas stove	47.2%	63.5%
Paraffin stove	50.0%	55.2%

*Foods requiring up to two hours in the RHC (rice, porridge).
**Foods which need two to five hours in the RHC (samp, oxtail).

Having demonstrated that the RHC could be used to cook local foods in conventional cooking vessels and save significant quantities of fuel, the next step in the process was to gather substantial user experience.

The User Test

The user test was designed to get five percent of the households in Ditshegwane and five percent in Shoshong to use the RHC for a one-month period. That was the minimum period in which it was felt that users could develop sufficient experience with the RHC to yield meaningful results. In order to gain experience quickly, it was decided to use the commercial Wonderbox rather than have users construct their own. At the end of the "free" trial period, participants would be offered the chance to purchase the RHC or to attend a workshop to learn to make one.

The strategy for getting participants was different in the two villages. In Ditshegwane, teachers and extension workers were asked to participate, as they seemed most interested and likely to be able to afford the device. In Shoshong, the women's organizations were asked to participate again. The strategy was that following a demonstration, 40 women in Shoshong and 10 in Ditshegwane would be asked to take and try a Wonderbox for a month. During that month, the BRET project staff would make home visits twice a week during the first week and at least once a week after that to determine user problems; successes; frequency of use; preferred, suitable and unsuitable foods; and what people did while the food was in the RHC.

User-Test Results

Foods Cooked and Taste Results

In Ditshegwane, 10 extension workers and teachers participated in the test. No problems were reported in using the device. Tables 2 and 3 summarize the foods cooked and qualitative assessment of taste.

Table 2

Taste Results of RHC User Test in Ditshegwane (n=10)

Food	Number of Users	Taste Satisfactory	Taste Unsatisfactory
Soft porridge	8	8	0
Water	8	8	0
Mealie rice	7	4	3
Samp	5	1	4
Meat	4	2	2
Rice	2	2	0
Mealie meal	2	1	1
Steamed bread	1	1	0

Table 3

Taste Results of RHC User Test in Shoshong (n=19)

Food	Number of Users	Taste Satisfactory	Taste Unsatisfactory
Mealie rice	2	2	0
Samp	7	7	0
Meat	3	3	0
Rice	7	7	0
Mealie meal	8	8	0
Steamed bread	1	1	0
Cabbage	1	1	0

In the Ditshegwane group, samp, mealie rice and meat were the items most often found to be unsatisfactory. The Shoshong results, however, indicate that those foods can be cooked to taste, and users in Ditshegwane no doubt needed clearer instructions and more guided cooking practice to learn how to adjust the water quantity to suit their taste. It is also possible that during the "unattended" time, someone could not resist opening the RHC and/or the pot, thus losing heat and reducing the effectiveness of the RHC.

It is important, therefore, that people see clearly how to use the device, i.e., how to vary water quantities and time to get the best results, and are encouraged to experiment to get it "just right" for their own taste. Demonstrations must take this

into account as well as remind people that food will not cook well if they peek in the pot.

Frequency of Use

Frequency of use in Ditshegwane ranged from two to four times a week, and in Shoshong from one to three times a week. Shoshong users had more satisfactory experiences, yet used the cooker less frequently. The satisfaction may be explained by the relatively long history of the RHC in Shoshong, i.e., the women's groups described earlier had had six weeks' prior experience. It may be that it takes more than one month to develop the confidence and skill necessary to use the RHC regularly.

Use of Time Made Available

One of the issues in determining the benefits of the RHC is valuing the differences in cooking time versus the energy savings and other potential benefits. Time is not actually saved when using an RHC, but some time is made available for other activities because the food can cook unattended and can be left beyond the actual cooking time without burning. If the precise amount of water is put in the pot at the outset, there is also little chance of the food becoming overcooked.

An RHC requires more clock time, from start to finish, to prepare a meal, but since the food need not be attended or "watched" while it is in the RHC, it makes time available for other household chores or leisure activities. A project hypothesis was that since the RHC saves fuel and makes time available for other activities, women would be motivated to adopt and use the device.

BRET project staff felt that this time while the food was cooking unattended was an advantage of the RHC, but needed to determine what users actually did while the food was in the RHC. The round of user tests showed that several domestic chores were performed while food was cooking in the RHC. Ditshegwane participants, who were extension workers and teachers, responded as follows:

washing (clothes, dishes)	5
sleeping/resting	5
sweeping	2
going to school	2
visiting friends	1
nothing	1

In Shoshong, women reported the following activities:

fetching water	7
washing clothes	5
domestic chores	5
making bricks	2
cleaning house	1
ironing	1
visiting friends	1
nothing	0

The time that food is in the RHC is well used, with only one user reporting doing nothing. This represents only a partial solution to the dilemma, however, as it is unclear how much time is involved in the specific tasks mentioned, and the frequency of use of the RHC is not high. It does indicate that there is not an opportunity cost associated with the additional time required to cook using the RHC and that daily use of the RHC could substantially reduce the total amount of time required to complete domestic chores, including cooking. A more detailed analysis would need to consider time invested in domestic chores, time required to use the RHC optimally, and then the time "saved" while the RHC is unattended.

Homemade Versus Purchased

At the end of the user tests, participants were given the option to purchase or learn to make an RHC. In Ditshegwane, seven were returned, three were purchased right away, one person expressed interest in buying at a later date, and two people indicated an interest in making their own.

In Shoshong, of the 34 participants, 10 subsequently purchased RHCs. Eight more indicated that they would like to make their own. It appeared that among those interested in owning RHCs, there was more interest in purchasing than making them. Construction workshops were scheduled in both locations.

It is difficult to say precisely why there was a slight preference for purchasing over making RHCs. It is important to mention, though, that even in villages as remote as Ditshegwane, there is a high degree of exposure to imported consumer goods of reasonable quality. Batswana are increasingly in the consumer economy, and there is something attractive about the manufactured model as opposed to one that is homemade from recycled materials. While it is important that people understand how simply an RHC can be made, the homemade version must be perceived as being as attractive as the other and, of course, people must be willing to invest the time to gather materials and make the RHC.

Likes and Dislikes

In all cases, users indicated that they liked the RHC because it saved wood and time, prevented fire accidents, and allowed them to do other things while the food was in the RHC.

Conclusions

The user tests indicated that half of the people who had use of an RHC for a month wanted to purchase or make one. This was viewed as positive, as people used the RHC one to four times a week and had mixed success with it. The degree of satisfaction with taste varied, and people did make use of the time the food was unattended to perform other domestic activities. At the end of the user tests, it was decided that future dissemination work needed to address several issues:

- training/orientation/demonstration techniques that can provide enough success with a range of foods to motivate people to use the RHC most of the time;
- amount of staff/training time required;
- encouraging people to use and experiment with the RHC, given that adjusting water quantity and time food is in the RHC will result in well-cooked foods; and
- straightforward presentation of RHC limitations (e.g., meat will have a rather unappealing color unless colored spices or tomatoes are added; if food requires more stove time, it may be inconvenient to restart an open fire; etc.).

D. Field Testing and Pilot Education

Construction Workshop Demonstrations

This approach evolved out of the first demonstration of the RHC to participants in a seminar conducted by the Social and Community Development (S&CD) Department of the Gaborone Town Council. The BRET project conducted an RHC demonstration for the participants, and then was asked to return to teach them how to make one. The S&CD Department had sewing machines and was able to provide some fabric for cushions. Women were asked to bring insulating material, but only one was able to come up with any. Although four RHCs were constructed, only one was finished, with BRET supplementing the insulation.

As a result of this experience, it was decided that the time during which the demonstration food was being cooked in the RHC could in fact be used to construct an RHC. This was particularly true when the demonstration food was one requiring a long cooking time (e.g., samp or oxtail). The added value was that this activity provided a practical experience in using the time that food is unattended in an RHC. This proved especially valuable in the case of the Ditshegwane literacy groups, who could start the food and then proceed with lessons.

Additional demonstration and construction workshops were held with six groups totaling 172 participants:

35 - Molepolole BCW,
19 - Ditshegwane adult literacy groups,
8 - Tsholofelo Community Centre S&CD,
25 - Mookane RET workshop,
20 - extension worker seminars in Molepolole,
65 - extension worker seminars in Mahalapye.

At the two extension seminars, each participant made an RHC to take home and use. As of this writing, follow-up questionnaires had been returned by 23 of the Mahalapye participants. The results are described in Section III.E of this report.

Demonstration through construction workshops can provide practice with the RHC, as each participant can be encouraged to test her RHC in the workshop setting. Alternatively, workshop meals can be organized and cooked by participants. As mentioned above, this guided practice is key to building confidence. Although workshop time might be a constraint, it is recommended that people have the opportunity to cook those foods found to be the most difficult, i.e., mealie rice, samp and meat, and discuss ways to improve the appearance of meat cooked in the RHC.

Other Demonstrations

Demonstrations to stimulate interest were conducted in a number of settings with similar results. The settings included general kgotla meetings, clinics, seminars for home economics teachers, metal stove seminars, and during a three-month metal stove promotion.

The demonstrations generated a lot of curiosity and reached some 2,000 people. However, they did not generate motivation to actually purchase or make RHCs. In order to have a quick and effective demonstration, it is easiest to use rice, as it cooks rapidly. That in itself appears to be an advantage, but it is harder to believe that porridge can be cooked in the RHC because it is constantly stirred over an open fire. Thus, while it is a

slightly more complicated demonstration, it is recommended that if only one food can be cooked, that food should be porridge.

The decision to demonstrate the RHC with the metal stove was reversed when it became clear that the RHC in fact attracted so much attention as to detract from the metal stove promotion. People became so curious about and interested in what was happening with the RHC that it was difficult to promote the stove. In the end, it seemed that if the BRET project wanted people to focus on the stove, the RHC would have to be dropped from the demonstrations.

Demonstrations are effective for generating curiosity, and when another productive activity is available while the food is in the RHC, people can also experience the time-saving value. Demonstrators should be prepared to follow up with either construction workshops or sales information. Of the selected approaches, and with limited experience in each, it seems that demonstration combined with RHC construction resulted in the largest number of RHCs in use.

Follow-Up Studies

Six months after the extension worker seminars, questionnaires were sent to all participants to evaluate the results of their use of the RHC. Questionnaire responses were received from 23 of the 50 participants and are summarized in Table 4.

Table 4

Extension Worker Response to RHC Use (n=23)

Food Cooked	Satisfactory	Unsatisfactory
Samp	11	1
Rice	9	0
Meat	6	0
Mealie meal	5	0
Mealie rice	1	0
Dried melon	0	1

Very few problems were reported, and in 16 households no problems were encountered. Each of the following difficulties was reported once:

- rice, samp and mealie meal took a long time to cook,
- samp and dried melon were not well cooked,
- material for stuffing (insulation) was hard to obtain.

The first problem supports the notion that RHCs do take more clock time, although only one person mentioned it. Further investigation into the samp and dried melon problem is necessary, although it is most likely that the pot was not boiled long enough initially, or that a curious person peeked into the cushions. It could also be a matter of personal taste.

The questionnaire responses indicated that the time the food was unattended in the RHC was used to perform various domestic chores. Two people said they collected water, three shopped, four did washing, one ironed, one made mud bricks, one sewed and knitted, and one swept.

Frequency of use was reported to be as high as daily and as little as four times per week, which approaches the 50 percent frequency of use requirement determined in the economic analysis described in Section III.E. It also reinforces the BRET project hypothesis that all traditional foods can be cooked in an RHC.

In order to find clues regarding acceptability and promotion tips, these long-term users were also asked to rank their likes and dislikes concerning the RHC. Fuel savings, the availability of time for other activities, and the fact that children and others peeked into the RHC were the most frequently mentioned.

After six months of use, it was anticipated that any problems arising in keeping the cushions clean would have been addressed. In fact, this group of users kept the cushions clean by covering them with paper or cloth before inserting the pot, washing them, or cleaning them with a brush. No problems were reported.

This group showed a slight inclination toward making rather than buying RHCs, with eight people inclined to make them and seven inclined to buy. This may be due in part to the fact that these users all made their own and realize how simple it is.

Four of the extension workers indicated that 10 or more others were curious about the RHC and interested in owning one.

This long-term experience again points out that it does take time to develop proficiency and confidence in RHC use. People are more inclined to continue using the RHC if they have had enough initial experience to feel confident in doing so. Making the device creates a sense of ownership and demystifies it. This construction and guided use over a period of time in a workshop setting resulted in more satisfaction than the user tests. Since no problems were encountered with the insulation, the minimum lifespan of the owner-built model is six months.

E. Economic Analysis

The experiences described above provided the basis for an economic and financial analysis, conducted in June 1985, based on the number of RHCs constructed during the various workshops. The workshops provided the BRET project with the opportunity to record construction costs.

Computation of RHC costs was relatively straightforward. Although the model did not reach the stage of local production, the units produced during the workshops were costed at approximately P12, including BRET project staff training time, labor and materials. There has not been enough experience to know the actual life cycle of the RHC, and as mentioned earlier, it is likely that some insulation materials will need replacing as they mat.

Determination of the benefits to the user was a more complex issue. While the principal benefits are perceived to be fuel savings, assigning the value to fuel savings was limited by sketchy information on the price of firewood, and relatively little information at the time of the analysis on frequency of use of the RHC. An additional dilemma was presented by the increased cooking time.

Sensitivity analyses were conducted for various frequencies of use, costs per kilogram of firewood, and opportunity costs of additional cooking time (see Appendix D). The tests indicated that if fuelwood is valued at no less than three thebe per kilogram, the technology is used at least 50 percent of the time, and the opportunity cost of the extra cooking time is insignificant, then the RHC is economical. The argument could be made, however, that since people do in fact use the time that the food is in the RHC for other domestic chores, the time is at least a zero opportunity cost, if not a benefit.

F. Potential Market

The BRET project's experience to date indicates that skill and confidence in retained heat cooking develop over a period of

time. Also,the 50 percent frequency of use that users were approaching at the six-month point makes the RHC an economical investment. The number of users to date may be limited, but the potential market is near 60,000 households, according to ARD consultant Phillip LeBel in his report titled, "A Financial and Economic Analysis of Selected Renewable Energy Technologies in Botswana." This figure was derived for wood-burning households only, and when one considers that the RHC saves significant amounts of any fuel, one could say that all households not currently using an RHC constitute the true market.

In a study conducted for the BRET project in three towns and major villages, 576 households were asked if they would use an RHC if it saved 10, 20, 30, 40, or 50 percent of the wood currently used for cooking. At the 20 percent level of fuel savings, 50.5 percent of the responses were positive; at the 40 percent level, 62 percent were positive; and at the 50 percent level, 71.6 percent were positive. Since 40 percent is the minimum fuel savings, regardless of food or fuel, 62 percent of the households in towns and major villages could be said to constitute the market. This places the market figure at 37,200 households.

The study also indicates that of those potential users, 64.3 percent prefer to make rather than buy the RHC. Reaching this group might be possible through a concentrated effort to train one or two extension cadres in RHC use, construction and training.

IV. CONCLUSIONS

A. Technical

The RHC can be built by its owner, using strong cotton fabric for cushions and a wide range of insulating materials. Feathers, sawdust, discarded wool, thatch and old clothes have been used. Frequently, insulating material is difficult to find in villages or takes a long time to save (e.g., feathers). Concern has been raised about combustion of fabric and/or insulation, but none of the above-mentioned insulation materials will actually combust. The use of light synthetic fabric will result in melted cushion covers, but will not produce flames. Strong cotton or predominantly cotton fabric is recommended.

The range of RHC insulating materials yields satisfactory results as long as 10 centimeters of insulation surrounds the pot on all sides.

The lifespan of the various RHC insulation and cushion materials is unknown. The discarded wool was used for six months with no reported degeneration. The expected lifetime of the commercial model is at least three to five years.

The RHC has the potential for local production, and suitable cloth is imported and readily available. Polystyrene beads for insulation are not readily available and arrangements for regular import would need to be made with suppliers in Zimbabwe or South Africa.

The RHC is well suited for cooking the most popular foods in Botswana, saving 40 to 60 percent of any fuel used.

B. Economic

The estimated cost of the owner-made, BRET project RHC produced in workshops is estimated at P11.78. The imported commercial model is P16.00.

There is considerable debate about whether the RHC's extra cooking time is an opportunity cost or a benefit. One compromise, used in the economic analysis for the BRET project, puts the opportunity cost at zero.

RHC benefits include firewood saved and, potentially, time made available for other activities. The benefits are directly related to the value of firewood saved and frequency of RHC use.

Assuming an opportunity cost of zero for the extra cooking time and a zero rate of annual increase in the real fuelwood price, the benefit/cost ratio for the RHC is as follows:

Frequency of Use	B/C at 3t/kg	B/C at 4t/kg
100%	1.76	2.35
75%	1.32	1.76
50%	.88	1.17

Additional experience with long-term users may provide sufficient data to assign a benefit value to the extra cooking time.

C. Sociocultural

The predominant staple foods of Botswana--sorghum and maize ground to cook as porridge, and rice, maize rice and samp--are well suited for RHC cooking.

The foods, when cooked over an open fire or stove, require frequent stirring, and water is often added incrementally as the cooking progresses. While the RHC requires accurate judgment and measurement of water quantity from the outset, and the discipline to leave the container, cushions and pot unopened until the end of the minimum cooking time, people have been able to use the RHC successfully for all foods.

The taste of food and the extent to which it is under cooked, overcooked or just right, are highly subjective. Learning not to under- or overcook with an RHC is a matter of using the proper amount of water. Varying the quantity of water used and adding water only once require practice and confidence, as most traditional cooking is done in such a way as to allow for the addition of water at any point in time.

It takes time to build the skill and confidence necessary to successfully use the RHC.

On those occasions when two food items are cooked, the RHC is ideal, as one food can be put into the RHC quickly while the other cooks on the fire or stove.

The vast majority of RHC users are women, as might be expected of a cooking device, but a number of single male teachers and extension workers have also found the device to be valuable and use it.

A frequently stated advantage of the RHC is that it prevents fire accidents.

Direct feedback from users and potential multipliers indicates a slight preference for buying an RHC versus making one's own. The results of an energy use survey conducted in three towns and three major villages indicates a slight preference in the other direction. In any case, it is important that either a homemade or commercial model preserve the attractiveness that Botswana consumers, heavily influenced by the flow of goods from South Africa, have come to expect.

One aspect of preserving the attractiveness of RHCs may be to minimize emphasis on the suitability of recycled materials for cushions and insulation.

During the three to four months of winter, the evening fire is used not only for cooking, but for lighting, heating and social gathering, and the RHC does not fulfill all of those functions. However, the benefits of the RHC are expected to be optimal during the remaining 67 to 75 percent of the year. This is a problem with any cooking device designed to reduce consumption of firewood and is hardly a reason not to promote the RHC.

The notion of using blankets or old clothes to retain heat in a container is known in households where khadi, a fermented berry drink, is produced for sale. While this is a limited segment of the population, it indicates that the principle of retained heat is not entirely new.

D. Institutional

The RHC is an appropriate technology for individual households, as it saves fuel, is well suited for local foods, is affordable as a homemade or commercial device, and villagers and extension workers have been trained to use it successfully.

The RHC has minimal maintenance requirements, although the insulation and/or cushion fabric may require periodic replacement. The replacement period is unknown.

The RHC has to be seen to be believed. In demonstrations, it is important that people see a variety of foods, or at least common ones, being cooked. While rice makes a nice, short demonstration, porridge--the most commonly cooked food--is harder to imagine being cooked in an RHC, thus people should see that the RHC can indeed cook it well.

The highest degree of satisfaction is reported by individuals whose introduction to the RHC included practical and personal experience cooking a variety of foods. This is a critical factor in the dissemination of this technology. The RHC does take skill and confidence, which come only with practice. And because the taste of the food is dependent on the amount of

water added at the beginning of cooking, it is important to provide new users with opportunities to experiment "to taste."

The extension workers who attended the week-long seminars reported the greatest success with the RHC, after six months of use. These extension workers have regular cash incomes, and it is important to note that they still preferred to make rather than purchase their RHCs. Their investment in construction time likely accomplished two things; it increased their interest in using the device and demystified the technology--they know there is no magic to the device.

Extension workers also identified up to 20 people each who would be interested in having and using an RHC, indicating that the represented groups, i.e., adult educators, head teachers, family welfare educators and home economists, are likely multipliers.

Because the RHC requires demonstration and practice, it is likely that an intensive education process, i.e., demonstrations, construction and practice cooking, is most likely to have the biggest long-term impact.

Given the economics of the RHC, potential users should be encouraged to use the RHC for as many meals in a day as possible. This could be approached during the demonstrations, construction and practice as well as through scheduled follow-ups.

E. Energy

The RHC has the potential for saving 40 to 60 percent of any cooking fuel. This savings must be adjusted for frequency of use, and the only available analysis, Dr. LeBel's, is weighted to offset the additional cooking time issue. His analysis predicts a 13 to 14 percent aggregate fuel savings if the RHC were universally adopted. RHC use would result in a fuelwood savings of approximately 400 kilograms per household per year.

F. Summary

The RHC is demonstrated as an effective and acceptable way to cook local foods and conserve up to 60 percent of any cooking fuel. When used at least 50 percent of the time, it is an economic technology. Elements of effective dissemination include demonstrations, clear guidelines for cooking local foods and sufficient guided practice to develop confidence to use the RHC at least 50 percent of the time, and ideally for all meals. If the estimated 60,000 woodburning households in major villages

were reached, approximately 12,000 metric tons of fuelwood could be saved each year. The addition of those households cooking with paraffin, gas or electricity would result in even larger fuel savings nationwide.

V. RECOMMENDATIONS

As indicated above, the RHC is well suited as an energy-conserving cooking method for Botswana. A modest program of expanded dissemination is in order and should include the following activities.

Additional follow-up of current users should be undertaken after, for example, nine and 12 months of use to determine:

- change in frequency of use,
- estimated number of hours made available per week based on frequency of use,
- how to encourage more frequent use,
- changes in frequency with which certain foods are cooked,
- lifespan of cushions and insulation, and
- any unanticipated results of long-term RHC use.

Appendix E contains data sheets used by the BRET project which could be expanded or modified to incorporate the above. Appendix F contains a list of current users and their addresses. Current BRET project staff could conduct interviews as well as gather and record data. Assistance would be required to detail the questionnaires and analyze data.

Home economists, assistant community development officers and adult literacy assistants should be trained in:

- use and construction of RHCs in such a way that they gain sufficient confidence and proficiency to train others to use them; and
- methods for teaching others to use and construct RHCs.

Commercial sewing groups, e.g., BEDU, should also be trained as above. If they become convinced of the RHC's advantages, it is possible that the entire effort could become completely commercialized.

Patterns, samples and cookbooks should be provided to the groups intended to act as trainers. The resources and expertise for developing these materials as well as undertaking the above-mentioned training activities exist among the current BRET staff.

Based on the experience with the above-mentioned training efforts, a market study should be conducted to determine whether there is sufficient interest to justify commercialization.

Commercial groups should be assisted in determining whether local production of RHCs can be competitive with the homemade and/or imported commercial model.

If local production is viable, a national radio campaign (supported by the home economists, assistant community development officers and adult literacy assistants mentioned above) should be undertaken to publicize the benefits and availability of RHCs.

The activities related to potential commercialization of the RHC would require short-term expertise beyond the current skills of the BRET project staff, but staff input would be important.

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APPENDIX A

Technology Development, Dissemination and Assessment Model Used by the BRET Project

The technology development, dissemination and assessment approach used by the BRET project was the basis of ARD's original proposal to AID. That proposal outlined the general work plan for the project, including the following efforts and activities:

- redefining, refining and reassessing the BRET project's purpose and outputs, as well as searching for appropriate technologies for Botswana's rural areas;

- collecting necessary data for problem definition, analysis and resolution, not only in terms of technologies, but for awareness campaigns, extension and other project activities;

- selecting technologies based on "needs-driven," rather than "technology-driven," considerations;

- gathering relevant sociocultural, economic, technological, energy and organizational/ institutional data at the village level to understand the energy needs and technological potential in rural Botswana, beginning with energy surveys in pilot villages as the first step in an iterative planning process for choosing and transferring technologies;

- selecting technologies by moving through decision points related to goals, needs, social/cultural patterns and economic analysis;

- making adaptations in technologies used elsewhere, and in Botswana institutions and organizations;

- testing potential RETs in the laboratory, at the project's village training centers and in the field;

- completing additional surveys and similar data collection efforts, as already noted, necessary for the experimental process with various technologies; and

- developing clear objectives and the means for evaluating both project performance and technological innovations, including technical performance, financial and economic costs and

benefits, social and cultural acceptance, institutional appropriateness and transfer or extension strategies.

The BRET project employed and further developed ARD's process for technology development, from the perception of energy-related needs to promoting widespread use of technologies that meet those needs. This process (graphically presented in the figure on the following page) served as the basis for most of the activities undertaken during the project's life and guided the development of each RET. As the figure shows, the process appears to be basically linear, but does allow for feedback at major decision points. In this way, devices were modified, new ideas introduced and decisions made about technology production, dissemination and follow-up.

The Project as a "Learning Laboratory"

Overall, the BRET project employed a "learning laboratory" approach. Basic to this approach is the fact that efforts were needs-driven, as opposed to technology-driven. The fieldwork and needs assessment conducted as part of the village energy survey at the start of the project provided the initial impetus and foundation for subsequent technical activities. After energy needs in two of Botswana's rural villages had been assessed, technologies were matched to those needs, prototype devices constructed and tested, and finally, if a technology showed promise in meeting an identified need, limited field trials were conducted. Feedback is an integral element of the learning laboratory approach to ensure that any problems that arise during field trials can be addressed in the workshop. During the course of the project, the progress of each RET was plotted on a flow chart, and every device had to go through five major steps before it received public acceptance status. Only after a device had made it through the entire development and testing process was it considered for release to the general public.

General Description of the Technology Development Process

The BRET project was involved in research, development and dissemination of two categories of RETs, which moved through the technology development process in different ways, as is discussed subsequently for particular steps in the process. The two types of technologies were:

- rural domestic RETs, targeted at rural households to conserve fuelwood used for cooking, lighting and heating; and

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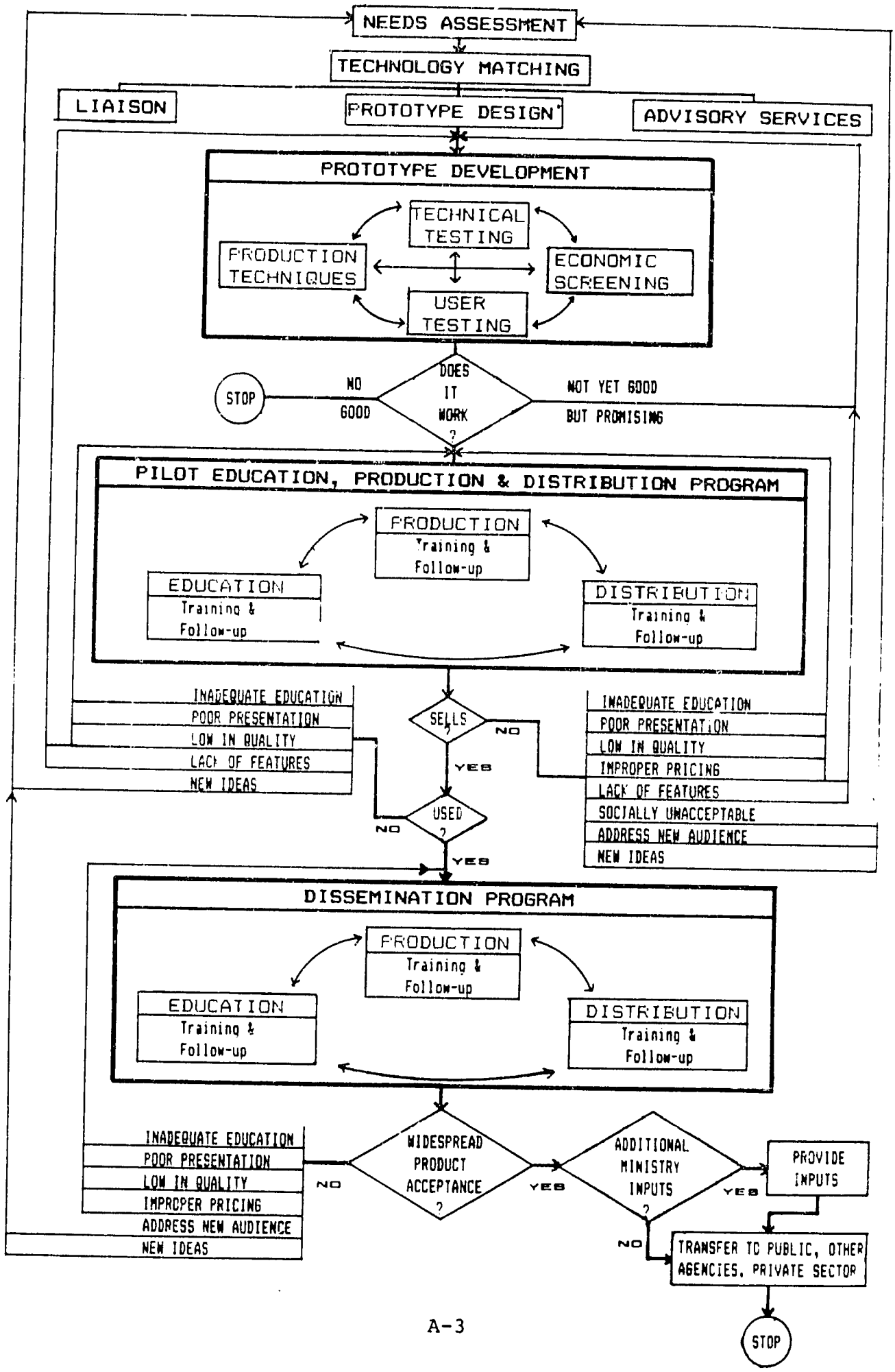
TECHNOLOGY DEVELOPMENT PROCESS



- institutional RETS, intended for community, district and government agencies for water pumping, small-scale electrification and building projects.

The technology development, dissemination and assessment process consisted of five distinct stages:

- needs and resource assessments,
- technology identification, matching and selection,
- prototype development and testing,
- comprehensive field testing and pilot education, and
- widespread dissemination or transfer to the public domain.

In addition, a specific analytical method was used during the process for technology assessment. It is described in a separate section below.

Community and entrepreneur involvement took many forms during the BRET project and was an essential part of every step in the technology development process. Since ARD was using a recognized community development framework, "community involvement" refers to the project's relationship with all individuals, leaders, organizations, and GOB staff and programs related to the geographic areas or technologies of interest. Community input was solicited through a number of activities, including surveys, discussions, interviews with leaders, conferences and seminars, consultations, and requests for assistance in evaluating particular devices or planned dissemination strategies.

Research and development was an essential aspect of the BRET project, with four different types of activities:

- social research and development into needs assessments, dissemination strategies and institutional capabilities;
- renewable energy resources assessments that involved the installation of monitoring equipment and subsequent data collection and analysis;
- development of new devices, such as the sheet metal stove, simple solar water heater and wind-driven mono pump; and
- field testing of off-the-shelf RETs under Botswana's conditions.

Since the project dealt with both technical and social matters, an interdisciplinary staff was needed to carry out its research and development efforts in both areas.

Five Stages in the Technology Development Process

One -- Needs and Resource Assessments

The first step in the process includes the assessment of the target population's actual or perceived needs. Needs can be identified through a number of sources and activities, such as interviews or surveys of the people or communities involved. Many institutions have relevant information about documented needs, and some have even had experience in attempting to meet those needs. This type of information can be gathered by interviewing staff members or reading reports. Some needs have been documented in reports on past studies and assessments as well as in national development plans. Thus, when developing a particular technology, the starting point for a needs-driven project is a clear picture of the need(s) that can be met by the particular technology under consideration.

The initial stage in technology development also includes an attempt to collect enough reliable data to make a realistic assessment of available amounts of renewable energy resources. In Botswana's case, these resources include biomass, firewood, wind and solar radiation. In some cases, there was only limited existing information on these energy sources, so it was necessary to develop data-gathering programs. Potential resources in terms of organizations, institutions, manpower and skills must also be assessed to aid in the selection of technologies and dissemination strategies. Finally, financial and economic resources must be assessed and considered.

Two -- Technology Identification, Matching and Selection

At this step in the development process, a complex issue is addressed--identifying potential technologies that can use the available resources to meet existing needs. It may be possible to utilize or modify a known RET, or an attempt can be made to develop a totally new device. Since the latter option requires considerable research and development time and resources, the BRET project focused on using or modifying existing technologies. However, its work on the wind-driven mono pump with RIIC approached the development of an entirely new technology. On the other hand, development of a new pedal-powered sorghum de-huller was investigated, but not pursued, because there would have been insufficient time during the project to complete the necessary resource assessment and research.

Three -- Prototype Development and Testing

Following needs identification and the selection of appropriate RETs, a number of potential technology designs are considered and prototype models developed. Actual working units are constructed and tested. Important considerations include both potential energy savings and information from the assessment of existing or potential social, institutional and construction skill resources for eventual production and dissemination of the device.

Actual working prototypes are tested in the research and development lab to determine how well they work, whether they are likely to satisfy identified needs with less work and increased energy efficiency, and the potential economic savings. Once these questions are answered, it is also necessary to consider potential social costs and institutional structures required to implement eventual construction and dissemination of the technology.

In the case of the project's institutional RETs, prototypes were installed in field settings to examine their operation under natural conditions and determine whether the devices could be operated and maintained by local technicians. From these tests, it is possible to estimate the kind of additional training required for operation and maintenance personnel. In the case of the BRET domestic technologies, these devices were constructed and/or used by villagers to assess their performance under fairly normal, daily use by ordinary people, not trained lab technicians. In each case, a thorough testing and data collection procedure was developed and employed.

Four -- Comprehensive Field Testing and Pilot Education

By the time the BRET project reached this step with a particular technology, it had already found that the device was more efficient and afforded potential energy savings in comparison to the technique(s) used previously. Still, some questions remained about the technology's performance under typical field conditions, whether potential savings would be actualized, and the skills and costs involved in maintenance and repair. Before proceeding with nationwide dissemination, any new RET should be operated in the field by many ordinary people and/or technicians in conjunction with careful monitoring. This step helps identify operational problems and training needs, and solidify plans for general dissemination. For the project's institutional technologies, this step was actually part of the data-gathering undertaken to answer the questions just noted.

Villagers and institutional representatives were invited to demonstrations of rural domestic RETs and installations of

institutional technologies to become acquainted with the potential of these devices to meet personal or institutional needs using existing renewable energy resources in Botswana. These working demonstrations proved to be much more informative and convincing than written information, theoretical discussions or even pictures.

Five -- Widespread Dissemination/Transfer to Public Domain

When a technology gets to the final step in the development process, it is ready to become part of the general social, cultural, technical and institutional scene. For rural domestic RETs, dissemination may involve large-scale GOB or government-supported campaigns. In some cases, these efforts will involve only the extension cadres, while in others, the combined efforts of extension personnel, producers and entrepreneurs will be required. The degree of involvement by various parties will depend on whether the technology is intended to be made by the owner or produced commercially. The dissemination of institutional RETs means developing national policies and programs, as well as the purchase and installation of technologies through numerous ministries, departments and district councils. In most cases, no single institution, ministry or department can handle the entire dissemination process, as it requires inter-organizational skills, planning and cooperation. With transfer to the public domain, project activities such as training local artisans to produce BRET stoves or fostering the private manufacture of wind machines and solar water heaters were the preferred strategy.

Technology Assessment

Whenever the BRET project was involved in technology assessment--primarily during stage three of the development process discussed above, but sometimes as part of other steps in the process as well--the model presented in this subsection was employed. All of the reports on individual technologies are organized according to the five areas involved in any substantial technology assessment:

- technical,
- economic/financial,
- social/cultural,
- institutional/infrastructure, and
- energy/environmental.

There are at least three topics involved in a technical analysis:

- the specifications, engineering design and component parts of the device;
- a study of the technology's performance--how much work it can do with what resources; and
- reliability and durability of the equipment, and concomitant needs for maintenance and repair during the technology's life span.

The economic/financial analysis involves a study of a technology's cost and the value of its benefits in comparison to other devices that can be used to accomplish the same task, regardless of whether they use fossil fuel or renewable energy resources. Both financial and economic analyses can be performed, and require reliable, valid financial figures for costs and benefits, including all hidden costs and subsidies, shadow prices and discount rates. In general, there are non-quantifiable factors that figure importantly in the decision-making process, which must be articulated in addition to the quantifiable parameters. Consequently, it is necessary to clearly specify all of the assumptions relating to these analyses. Common approaches, assumptions and types of data collected can be used for any analysis and comparison of technologies that perform a similar task, such as water pumping.

Technology introduction has an impact on existing social/cultural structures. At issue here are identifying these impacts, the sociocultural institutions that are affected, problems attending the introduction of a particular device, social and cultural obstacles to technology transfer, potential changes in social patterns required for technology acceptance, existing or new cultural or social structures that might be useful for introduction of the RET. Again, common assumptions should be articulated and agreed on for comparisons between existing and new technologies.

The institutional/infrastructure analysis concerns organizational resources needed to introduce and maintain the technology. Sometimes, such structures already exist; in other cases, they must be changed; and occasionally, new organizational structures have to be created. Training may be needed and this type of analysis concerns by and for whom, when, where, for how long, etc., as well as what existing or new coordinating and information-sharing groups might need to do. This portion of the assessment model relates to both the informal and formal sectors of the GOB, ministries, departments, districts, para-statal organizations, and private construction and manufacturing firms.

In the energy resource/environmental analysis, it is important to consider Botswana's sunny, hot climate and delicate vegetation base. For instance, increases or decreases in fuelwood consumption could have a substantial environmental impact. This type of analysis is also concerned with how the energy utilized by a particular technology fits into national energy goals and renewable energy objectives, in terms of the energy source used, resources saved and overall effect.

In summary, this technology assessment model can be used for any technology by any organization. Although some groups could complete the entire assessment, it may be more efficient to make it an inter-organizational task, utilizing the competencies of relevant ministries, departments and para-statal agencies to carry out the five types of analyses that make up the total assessment. This sort of inter-organizational approach develops knowledge and potential interest in a technology that crosses disciplinary and organizational lines, which would aid in the eventual dissemination process. If such an approach is taken, the overall technology assessment must be managed by a team that has the necessary interdisciplinary technical, social and organizational skills.

APPENDIX B

BRET Project Reports

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NO-FUEL COOKING IN THE WONDERBOX..

PART 1: *HOW IT WORKS*

BRET

This Guidebook is produced by BRET, a project of the Ministry of Mineral Resources and Water Affairs.
Researched and Written by **Baintlafatsi Letsemane.** Editing, Illustration and Design by Jan Swartzendruber.

APPENDIX C

Wonderbox Cooking Instructions and Recipes

HOW THE WONDERBOX WORKS

THE SIMPLE SOLUTION

TO EVERYONE'S FUEL PROBLEM . . .

FUEL PRICES TOO HIGH

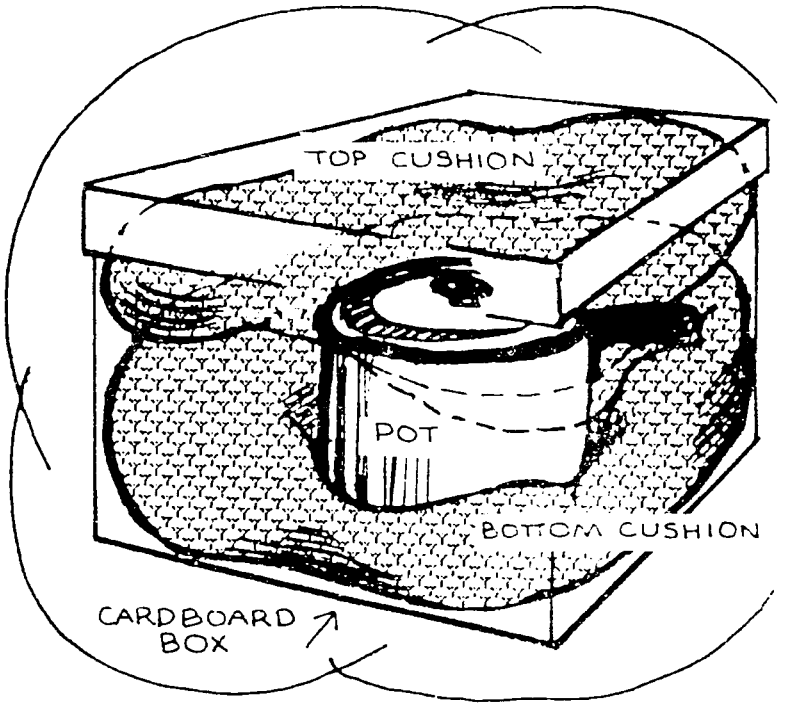
Everything is expensive these days, including cooking fuels. Even wood costs a lot because it is becoming scarce. If you collect wood instead of buying it, you have to go further each time. Buying gas, paraffin or electricity will squeeze out your last thebe. Still, in a few weeks, you have to buy more. There must be a way to eat without consuming so much fuel! Luckily, there is.

THE NO-FUEL COOKER

There's a very simple system (you can even make it yourself★) at the heart of a Wonderbox. Two thick cushions surround your boiling food, and are enclosed in a cardboard box. The Wonderbox uses no fuel, but it **saves** the heat from your expensive fire, and in a matter of time, the food slow-cooks with absolutely no help from you — and no fuel used.

HOW IT WORKS

The big cushion at the bottom of the box is like a nest cuddling the bottom half of your pot. The food must be taken off the stove or fire at a vigorous boil, already covered with a well-fitting lid, and placed deep into the bottom cushion. Then you tuck the top cushion around the top half of the pot, being careful that the two cushions meet all around. Set your box away from cool breezes, and go about your work. Your meal will be cooked and still hot at the appointed time.



THE WONDERBOX will save 40-60% of your fuel bill with no-fuel slow-cooking. Simple - and it works!

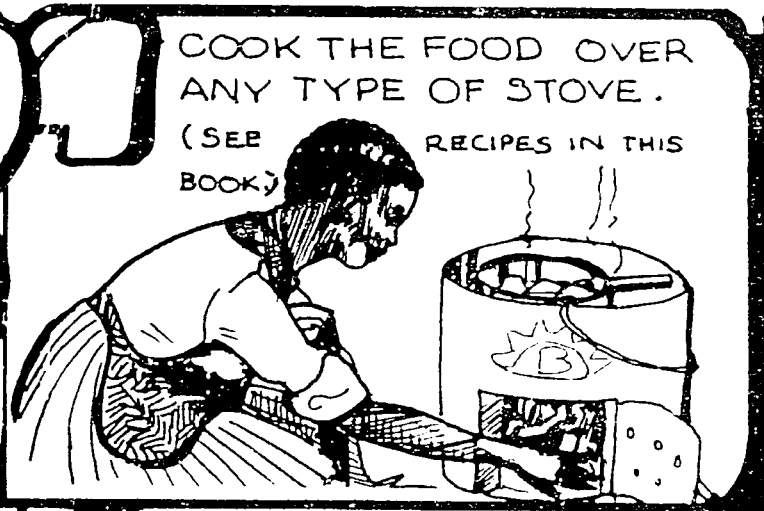
★ **PART 2** of this booklet contains **recipes** . . . . For cooking times and directions, see recipe side

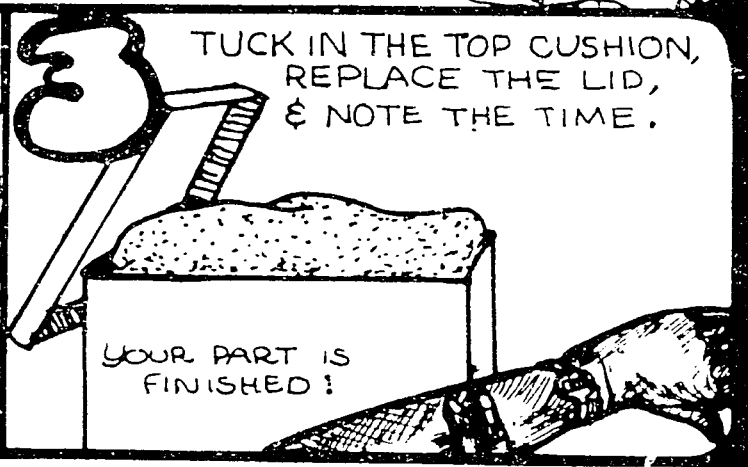
IF YOU DON'T ALREADY HAVE A WONDERBOX . . . you can buy one from the Energy Unit, Ministry of Mineral Resources and Water Affairs, Bank of Botswana Bldg., P. Bag 0018, phone 52454. ★ Another source is Mrs. M. Seligmann, 3132 Kgalagadi Way, Gaborone, phone 52727 or 51515. ★ BOTH BOXES COST P16.00.

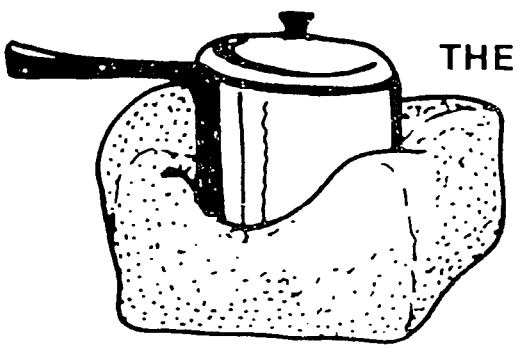
. . . TO MAKE YOUR OWN WONDERBOX, SEE INSTRUCTIONS ON PAGE 3.

THREE SIMPLE STEPS

TO CORRECTLY USING THE WONDERBOX . . .







THE WONDERBOX WORKS WHEN . . .

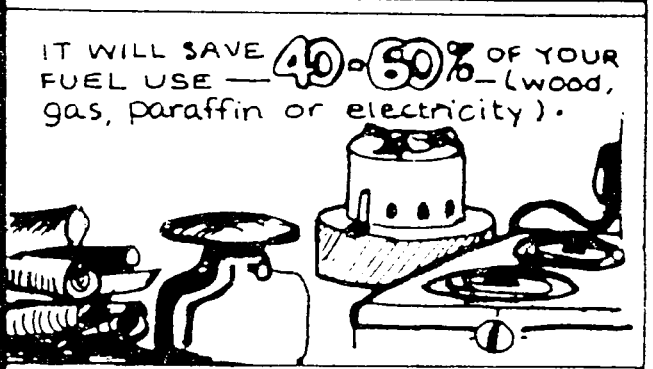
— the food boils about 1/5 of total slow-cooking time and is still boiling when transferred to the Wonderbox;

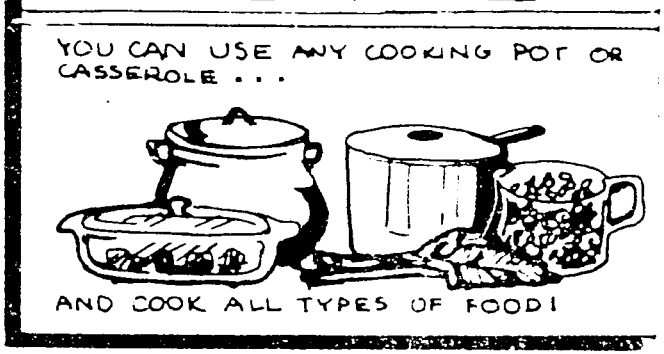
— the cooking pot has a tight-fitting lid and the cushions around the pot are big enough to completely cover it.

— you **NEVER** open the box or kettle during the slow-cooking time.

FACTS

ABOUT THE WONDERBOX



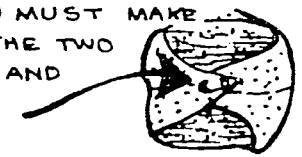


MAKE YOUR OWN WONDERBOX ...

CHOOSE A MATERIAL: A sturdy cotton is best because synthetics can't take the heat.

CHOOSE A PATTERN: (RIGHT) The "DIAMOND PATTERN" gives you two square-based cushions, each using 4 pieces. A "nest" is shaped in the bottom cushion.

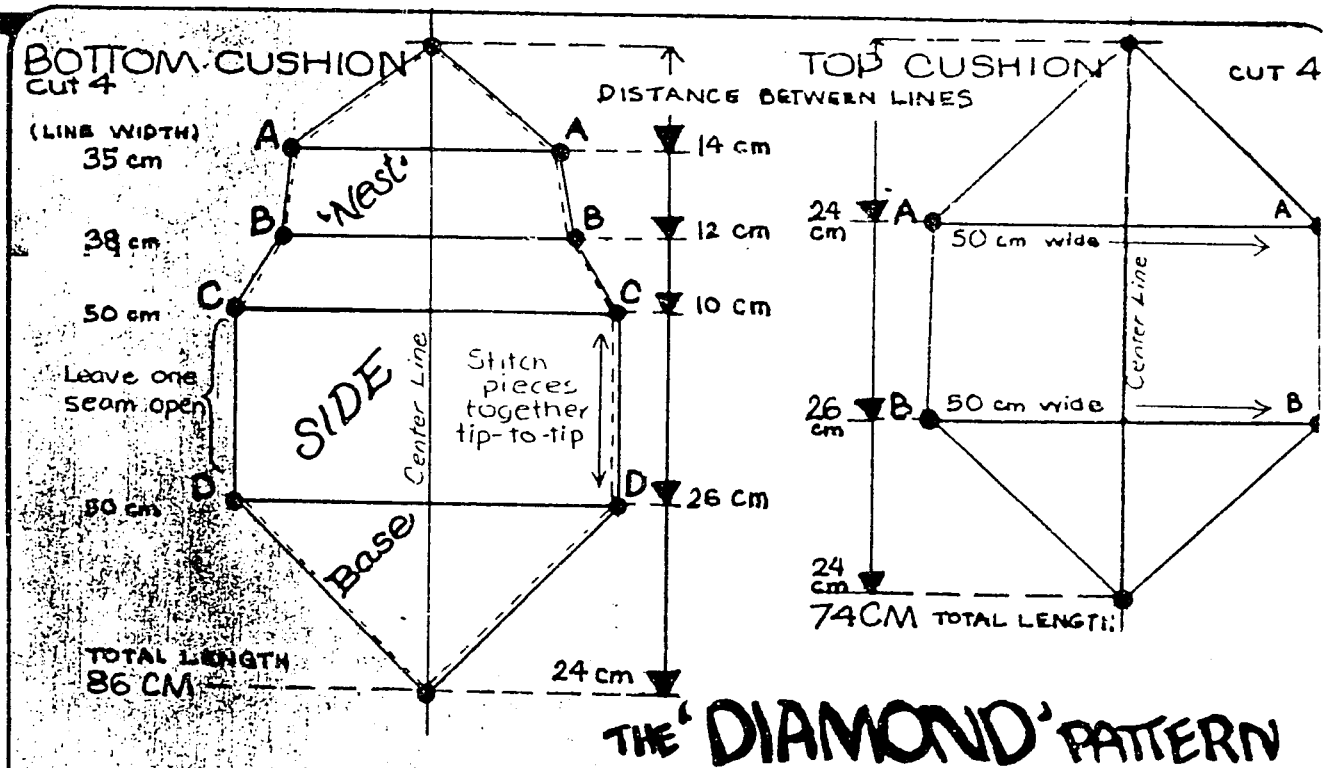
The "BAG PATTERN" (BELOW) is easier to sew and takes less material. (YOU MUST MAKE A BASE BY FOLDING THE TWO BOTTOM CORNERS IN AND PINNING TOGETHER.)



STUFF IT!

The ideal stuffing material is polystyrene beads, which insulate well, are durable & washable.

Polystyrene pieces (such as molded packing material from radios, cameras, etc.) can be grated into small pieces. Other types of stuffing are sponge, sawdust, chicken feathers, shredded newspapers, and shredded cloth.

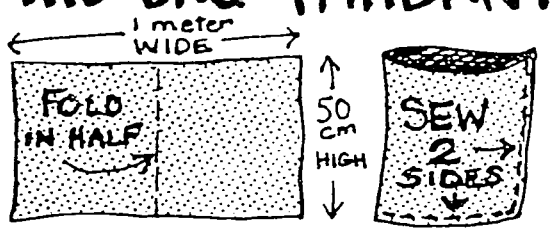


THE 'DIAMOND' PATTERN

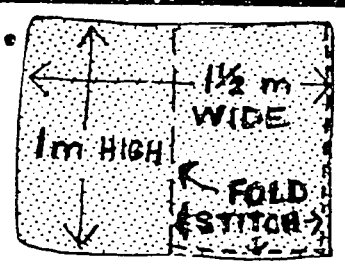
DRAW THE PATTERN:

- Measure from the top of the centre line down to crossways line A, B, C, and D. Mark and draw the crossways lines at right angles to the centre line.
- Mark the widths of lines A to D by dividing each width given in half and measuring each way from the centre line.
- Join all the points using a ruler. Cut out your finished pattern. Repeat for second cushion.

'THE BAG' PATTERN...

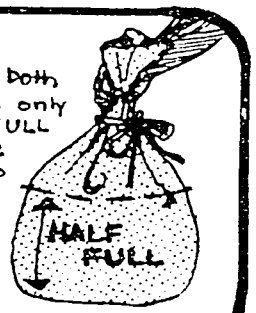


TOP CUSHION



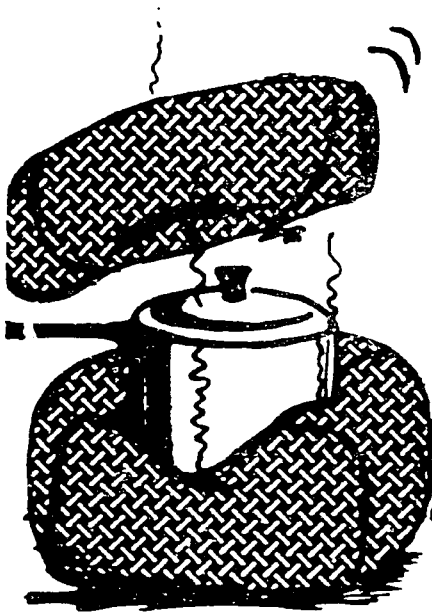
BOTTOM CUSHION

STUFF both cushions only HALF FULL and tie close to top of bag.



SEW IT: With right sides together, match the sides of two pieces of the bottom cushion, from centre top to centre bottom. Stitch from top to bottom. On the fourth side, leave open the side section for turning and stuffing. SAME for top cushion.

(For Recipe Section, Flip Booklet Over)



RECIPES for the WONDERBOX

BRET

Brought to you by the Botswana Renewable Energy Technology Project of The Ministry of Minerai Resources and Water Affairs, Government of Botswana

WONDER COOKING

GRAINS

Notice that each recipe gives a RATIO OF WATER TO GRAIN. It really is important to measure carefully for the best-tasting results!

EALIE RICE

IO: 2 1/2 parts water to 1 part mealie rice.

Bring water to a boil.
Add mealie rice and boil for 10 minutes.
Salt and season before removing pot from stove or fire.
Transfer covered pot quickly to Wonderbox and slow-cook for 45 minutes.

minutes boiling
minutes slow-cooking

C E

cooks quickly, and it is very easy to over- it. **Be very careful not to add too much er.**

IO: 2 parts water to 1 part rice.

Bring salted water to a boil.
Add rice and let boil for 5 minutes.
Transfer the covered pot quickly to the Wonderbox and slow-cook for 35 to 40 minutes.

minutes boiling
40 minutes slow-cooking

BOGOBE

Make a paste ahead of time using cold water and one half the sorghum flour you will cook.

RATIO: 3 parts water to 2 parts flour.

- Bring water to the boil.
- Add the paste to the boiling water and stir until the mixture is smooth.
- Add more bopi until medium stiffness is reached.
- Cook for 10 minutes, stirring occasionally.
- Transfer covered pot quickly to Wonderbox and slow-cook for 45 minutes.

10 minutes boiling
45 minutes slow-cooking

SAMP AND BEANS

Samp and beans take the same amount of time to cook, and in this recipe they must be mixed together when boiling and slow-cooking.

RATIO: 3 parts water for every 1 part samp or beans.

- Soak samp and beans together overnight.
- Bring the water to a boil.
- Add the soaked samp and beans and boil them for 40 minutes.
- Salt and season before removing pot from stove or fire.
- Transfer the covered pot quickly to the Wonderbox and slow-cook for 5 hours.

40 minutes boiling
5 hours slow-cooking

PHALETSHE

Make a paste ahead of time, using water, a pinch of salt and half of the mealie meal you will cook.

RATIO: 3 parts water to 2 parts mealie meal.

- Bring water to boil.
- Add all the paste and stir until mixture is smooth. Sprinkle more mealie meal until medium thickness is reached.
- Cook for 10 minutes, stirring occasionally.
- Transfer covered pot quickly to Wonderbox and slow-cook for 40 minutes.

10 minutes simmering
40 minutes slow-cooking

WONDER COOKING

MEATS

THE SECRET OF GREAT MEAT DISHES FROM THE WONDERBOX IS THE LONG COOKING TIME, DURING WHICH SEASONINGS ARE ABSORBED AND THE MEAT BECOMES TENDER.

SEASON YOUR MEAT WELL BEFORE PUTTING THE POT INTO THE WONDERBOX!

OXTAIL STEW

Oxtail, though a very tough meat, is also highly flavorful and is especially well-suited to Wondercooking. During the slow, low-heat cooking process, the meat reaches its maximum flavor and tenderness.

RATIO: 2 parts water to 1 part oxtail.

- Cut into small pieces between tail sections or chop through bones. Fry quickly in small amount of oil to brown the meat.
- Add water to the pot, and bring to a boil.
- Cut up any vegetables you have — potatoes, onions, green beans, carrots, squash, etc. Add these to the pot.
- Season with salt, pepper, garlic and herbs to taste.
- Boil for 40 minutes (You may add certain vegetables later during this period to prevent over-softening).
- Transfer the covered pot quickly to the Wonderbox and slow-cook 4 — 5 hours.

40 minutes boiling
5 hours slow-cooking

MEAT SAUCE

This recipe makes a good gravy or sauce to be eaten with rice or porridge. Any meat — beef, goat, lamb, etc — will do.

- Cut onions and tomatoes into small pieces and cube the meat.
- Heat a small amount of oil and add the vegetables, frying them lightly while stirring.
- Add the meat to the oil and fry until brown.
- Season to taste with salt, pepper, garlic, etc.
- Add water to nearly cover the meat and vegetables; bring to a boil and cook for 7 minutes.
- Transfer the covered pot quickly to the Wonderbox and slow-cook for 1 hour.

5 minutes frying
7 minutes boiling
1 hour slow-cooking

MOGODU (STOMACH, TRIPE)

Stomach is an economical cut of meat, and an especially nutritious choice. Because it takes a long time to become tender, you will save a lot of fuel with the Wonderbox.

RATIO: 1 part water to 3 parts mogodu.

- Wash the mogodu and cut it up in small pieces.
- Put mogodu and cold water into pot at the same time. Add seasonings.
- Bring water to boil and boil vigorously for 40 minutes.
- Transfer the covered pot quickly to the Wonderbox and slow-cook for 5 hours.

40 minutes boiling
5 hours slow-cooking

WONDER COOKING

VEGETABLES

DO YOU LIKE A VEGIE WITH A WEE BIT OF CRUNCH? THEN COOK THEM IN T IN THE WONDERBOX WITH ALMOST NO WATER AT ALL!

VEGETABLES ALREADY CONTAIN WATER, SO THEY NEED VERY LITTLE TO COOK. TOO MUCH WATER JUST WASHES OUT VITAMINS!

SPINACH

Soggy spinach tastes awful because the body of the leaves breaks down and the natural juice of the leaf is lost. Add no water to this recipe and try for **a soft — but not spineless — leaf.**

- Cut up a few onions into thin rings or fine pieces.
- Heat a small amount of oil and fry the onions until they just turn transparent.
- Wash the spinach to remove grit from its wrinkled leaves; shake off excess water, then add the leaves to the oil.
- Add salt and seasoning and fry for only 3 minutes before covering the pot.
- Wait 30 seconds while the heat fills the covered pot, then transfer it quickly to the Wonderbox.
- Slow-cook for only 20 minutes.

6 minutes (total) frying
20 minutes slow-cooking

MOROGO (DRIED BEAN LEAVES)

All of the water has been dried out of these very concentrated young bean leaves; thus one must add one part water to each part morogo to restore their moisture and to loosen up the dried clumps.

- Add 1 part water to 1 part morogo in a pot and bring water to a boil.
- Cook for 5 minutes; stir to break morogo apart.
- Add salt and seasonings.
- Cover the boiling pot and transfer it quickly to the Wonderbox.
- Slow-cook for 15 minutes.

5 minutes boiling
15 minutes slow-cooking

CABBAGE

- Cut cabbage into chunks
- Heat a small amount of oil and fry lightly while stirring.
- Add salt and seasoning and continue frying for 5 minutes.
- Add a spoon or two of water only and cover the pot immediately to capture the steam.
- Quickly transfer covered pot to the Wonderbox and slow-cook for 20 minutes.

5 minutes frying
20 minutes slow-cooking

APPENDIX D

Sensitivity Analysis of Retained Heat Cookers

(from Financial and Economic Analysis of Selected Renewable Energy Technologies in Botswana, Phillip LeBel, Ph.D., Associates in Rural Development, Inc., July, 1985).

Given the three-year estimated lifetime of a retained heat cooker, the economics of this technology depend less on differences in the rate of discount used than they do on the estimation of specific costs and benefits. For this reason, a broad range of tests incorporating differing values of costs and benefits has been included in the analysis, the results of which are reported in Tables XV and XVI, along with a sample output test in Table XVII.

In Table XV, a financial analysis based on a one hundred percent upper limit use rate of the retained heat cooker has been done for differing values of the following variables: the price of fuelwood energy savings, different production unit cost models, differing assumptions regarding the rate of increase in the real price of fuelwood cooking energy, and differences in the value that one attaches to the opportunity cost of extra cooking time. What these tests show is that as long as one uses the retained heat cooker for one hundred percent of household basic meals, the crucial variables turn out to be the per kg price of fuelwood energy savings as well as the opportunity cost of extra cooking time. If the rate of increase in the real price of energy is zero, as long as fuelwood energy savings are valued at least at a price of 3 thebe per kg with a corresponding opportunity cost of extra cooking time valued at less than 1 thebe per hour, then the retained heat cooker is economic to households. If one allows for a five percent annual rate of increase in the real price of fuelwood energy, then even if the opportunity cost of extra cooking time rises to 1 thebe per hour, for wood energy prices of at least 4 thebe per kg the retained heat cooker is still economic. What makes this so problematic is that there is no readily discernible basis with which to assign a zero or positive opportunity cost for extra cooking time.

Even if one did not have to contend with the opportunity cost of extra cooking time, an equally difficult issue surrounding the assessment of retained heat cookers is whether they would be used for up to one hundred percent of household cooking time. In Table XVI, a second set of financial analysis

Table XIV

Value of Base Year Annual Savings from BRET Retained Heat Cooker

For 1985, Botswana's national fuelwood consumption is expected to be at 174,160 tonnes of oil equivalent. At .35 physical tonnes of fuelwood per tonne of oil equivalent, this is equivalent to 497,600 tonnes of fuelwood, which when divided by the projected 1985 population yields a per capita annual level of fuelwood consumption of .4539 tonnes, or 1.24 kg per day. With an estimated household size of 5.81 persons, this translates into a daily household consumption of fuelwood of 7.2251 kg, which on an annual basis yields 2637.17 kg of fuelwood. In the table below, alternative possible levels and values of fuelwood savings obtainable by a household's purchase of a BRET retained heat cooker are given for purposes of economic evaluation. In all cases, the reference is in terms of the quantity and value of savings in terms of the no-retained heat cooker case of 2637.17 kg of fuelwood per household per year.

1. Percentage Usage of RHC:	10%	25%	50%	75%	100%
2. Quantity of Wood Energy Saved per Year, in Kg.	39.74	99.34	198.68	298.02	397.36
3. RHC Wood Energy Savings as a Percentage of Household Annual Wood Energy Consumption:	1.5%	3.8%	7.5%	11.3%	15.1%
4. Annual Pula Value of Fuelwood Saved with kg price at:					
a. 3 thebe	1.19	2.98	5.96	8.94	11.92
b. 4 thebe	1.59	3.97	7.95	11.92	15.89
c. 5 thebe	1.99	4.97	9.93	14.90	19.87

Sources: The range of price estimates has been based on sample fuelwood prices reported in recent energy surveys conducted throughout Botswana (Oki 1984, Gay 1985, ODA 1985). The range of fuelwood savings potential of the BRET retained heat cooker has been based performance data from BRET technical tests listed in Table XII.

Table XV

Sensitivity Analysis of BRET Retained Heat Cookers - I
(based on financial analysis and 100 percent use rate)

	With the Opportunity Cost of Extra Cooking Time Per Hour Valued at:			
I. Basic Assumptions:	0 thebe	.5 thebe	1 thebe	1.5 thebe
A. 0 Rate of Increase In Real Fuelwood Price				
B. 6 % Discount Rate				
C. 3 thebe per kg/wood				
D. 397.36 kg wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.78				
b. Results:				
i. NPV	13.03	3.91	-5.21	-14.33
ii. IRR	Positive	85.51%	Negative	Negative
iii. B/C ratio	1.62	1.18	0.74	0.30
2. South African Comm.Model				
a. Price: P16.00				
b. Results:				
i. NPV	8.81	0.30	-9.43	-18.55
ii. IRR	139.43%	3.07%	Negative	Negative
iii. B/C	1.35	0.98	0.62	0.25
II. Basic Assumptions:				
A. 0 Rate of Increase In Real Fuelwood Price				
B. 6% Discount Rate				
C. 4 thebe per kg/wood				
D. 397.36 kg wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.78				
b. Results:				
i. NPV	24.28	15.16	6.02	-3.08
ii. IRR	Positive	Positive	161.10%	-34.64%
iii. B/C ratio	2.17	1.73	1.29	0.85
2. South African Comm.Model				
a. Price: P16.00				
b. Results:				
i. NPV	20.06	10.94	1.80	-7.30
ii. IRR	9,678.61%	203.62%	24.62%	-137.36%
iii. B/C	1.80	1.43	1.07	0.70

	With the Opportunity Cost of Extra Cooking Time Per Hour Valued at:			
	0 thebe	.5 thebe	1 thebe	1.5 thebe
III. Basic Assumptions:				
A. 0 Rate of Increase in Real Fuelwood Price				
B. 6 % Discount Rate				
C. 5 thebe per kg/wood				
D. 397.36 kg wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.78				
b. Results:				
i. NPV	35.56	26.43	17.30	8.19
ii. IRR	Positive	Positive	Positive	305.59
iii. B/C	2.71	2.27	1.83	1.39
2. South African Comm.Model				
a. Price: P16.00				
b. Results:				
i. NPV	31.34	22.21	13.09	3.97
ii. IRR	Positive	Positive	304.24%	50.98%
iii. B/C	2.25	1.89	1.52	1.15
IV. Basic Assumptions:				
A. 5 % Rate of Increase in Real Fuelwood Price				
B. 6 % Discount Rate				
C. 3 thebe per kg/wood				
D. 397.36 kg wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.78				
b. Results:				
i. NPV	14.68	5.56	-3.57	-12.06
ii. IRR	Positive	113.72%	-34.04%	Negative
iii. B/C	1.70	1.26	0.82	0.41
2. South African Comm.Model				
a. Price: P16.00				
b. Results:				
i. NPV	10.43	1.34	-7.78	-16.28
ii. IRR	158.50%	18.23%	-141.99%	Negative
iii. B/C	1.41	1.05	0.68	0.34

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	With the Opportunity Cost of Extra Cooking Time Per Hour Valued at:			
	0 thebe	.5 thebe	1 thebe	1.5 thebe
V. Basic Assumptions:				
A. 5 % Rate of Increase in Real Fuelwood Price				
B. 6 % Discount Rate				
C. 4 thebe per kg/wood				
D. 397.36 kg.wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.78				
b. Results:				
i. NPV	26.48	17.36	8.22	-0.88
ii. IRR	Positive	Positive	206.04%	-4.59%
iii. B/C	2.27	1.83	1.39	0.95
2. South African Comm.Model				
i. NPV	22.26	13.14	4.00	-5.10
ii. IRR	10,407.63%	234.61%	45.25%	-31.58%
iii. B/C	1.89	1.52	1.16	0.79
VI. Basic Assumptions:				
A. 5 % Rate of Increase in Real Fuelwood Price				
B. 6 % Discount Rate				
C. 5 thebe per kg/wood				
D. 397.36 kg.wood saved				
E. RHC Model:				
1. BRET Del.Prod.Cost				
a. Price: P11.;78				
b. Results:				
i. NPV	38.25	29.12	19.99	10.88
ii. IRR	Positive	Positive	Positive	375.32%
iii. B/C	2.84	2.40	1.96	1.52
2. South African Comm.Model				
a. Price: P16.00				
b. Results:				
i. NPV	34.03	24.90	15.77	7.27
ii. IRR	Positive	Positive	347.21%	86.14%
iii. B/C	2.36	1.99	1.63	1.29

Table XVI

Sensitivity Analysis of BRET Retained Heat Cookers - II

Listed below are sensitivity test results for the BRET retained heat cooker based on a financial analysis, a zero opportunity cost of extra cooking time, and variable assumptions regarding the percentage of cooking that is done with the retained heat cooker.

	With per Kg Fuelwood Energy Savings Valued at:								
	3 thebe			4 thebe			5 thebe		
	NPV	IRR	B/C	NPV	IRR	B/C	NPV	IRR	B/C
I. Basic Assumptions:									
A. Zero Rate of Annual Increase in Real Fuelwood Price									
B. Percentage of Meals Cooked With RHC:									
1. 100%	14.7	Pos.	1.76	25.9	Pos.	2.35	37.2	Pos.	2.94
2. 75%	6.2	295%	1.32	14.7	Pos.	1.76	23.1	Pos.	2.20
3. 50%	-2.3	-32%	0.88	3.4	100%	1.17	9.0	2045%	1.47
4. 25%	-10.7	Neg.	0.44	-7.9	Neg.	0.58	-5.0	Neg.	0.73
5. 10%	-15.7	Neg.	0.17	-14.7	Neg.	0.23	-13.5	Neg.	0.29
II. Basic Assumptions:									
A. Five Percent Rate of Annual Increase in Real Fuelwood Price									
B. Percentage of Meals Cooked With RHC:									
1. 100%	16.3	Pos.	1.85	28.1	Pos.	2.47	39.9	Pos.	3.08
2. 75%	7.5	339%	1.39	16.3	Pos.	1.85	25.2	Pos.	2.31
3. 50%	-1.4	-17%	0.92	4.5	125%	1.23	10.4	2269%	1.54
4. 25%	-10.3	Neg.	0.46	-7.3	Neg.	0.61	-4.3	Neg.	0.77
5. 10%	-15.6	Neg.	0.18	-14.4	Neg.	0.24	-13.2	Neg.	0.30

Table XVI

BRET Retained Heat Cooker
Financial Analysis

	Period:	1.00	2.00	3.00
A.Model: BRET RHC "Wonderbox"	Assumptions:			
1. Technical parameters:				
a.Annual Wd.Eq.Energy Saving	7%			
b. RHC life	3.00			
c. Replace box frame	2.00			
d. Replace cloth liner	2.00			
e. Replace top	2.00			
f. HH kg/p.a. Wd.En.saved	198.68	= 50 percent Use Rate		
2. Economic parameters				
a. Discount rate	.06			
b. Shadow wage rate	1.00			
c. Shadow For.Exch. rate	1.00			
d. RHC Selling Price	16.00			
e.Ann.Rate Wd.Eq.Price Increase	0	Percent		
f.Price per kg.Wd.En.Equiv.	5	thebe		
B. Costs:	Pula:			
1. BRET RHC Selling Price	16.00	16.00		
2. Replacement box frame	4.50			4.50
3. Replacement cloth liner	3.75		3.75	
4. Replacement top	1.50		1.50	
5. Annual Cost Flow		16.00	5.25	4.50
6. Discounted Annual Costs		16.00	4.95	4.00
7. Present Value of Costs	24.96	Pula		
C. Benefits	Pula:			
1. Value of Wd.En.Equiv.saved	9.93	9.93	9.93	9.93
2. Value of Added Cooking Time	.00	.00	.00	.00
3. Annual Benefit Flow		9.93	9.93	9.93
4. Discounted Annual Benefits		9.93	9.37	8.84
5. Present Value of Benefits	28.14	Pula		
D. Financial Evaluation:				
1. Net Present Value	3.18	Pula		
2. Internal Rate of Return	40.69	Pct.		
3. Benefit-Cost Ratio	1.13			

Notes:
a. RHC selling price based on BRET Delivered Production Cost

Table XVII

BRET Retained Heat Cooker
Financial Analysis

		Period: 1.00	2.00	3.00
A.Model: BRET RHC "Wonderbox"	Assumptions:			
1. Technical parameters:				
a.Annual Wd.Eq.Energy Saving	7%			
b. RHC life	3.00			
c. Replace box frame	2.00			
d. Replace cloth liner	2.00			
e. Replace top	2.00			
f. HH kg/p.a. Wd.En.saved	198.68 = 50 percent Use Rate			
2. Economic parameters				
a. Discount rate	.06			
b. Shadow wage rate	1.00			
c. Shadow For.Exch. rate	1.00			
d. RHC Selling Price	16.00			
e.Ann.Rate Wd.Eq.Price Increase	0 Percent			
f.Price per kg.Wd.En.Equiv.	5 thebe			
B. Costs:	Pula:			
1. BRET RHC Selling Price	16.00	16.00		
2. Replacement box frame	4.50			4.50
3. Replacement cloth liner	3.75		3.75	
4. Replacement top	1.50		1.50	
5. Annual Cost Flow		16.00	5.25	4.50
6. Discounted Annual Costs		16.00	4.95	4.00
7. Present Value of Costs	24.96 Pula			
C. Benefits	Pula:			
1. Value of Wd.En.Equiv.saved	9.93	9.93	9.93	9.93
2. Value of Added Cooking Time	.00	.00	.00	.00
3. Annual Benefit Flow		9.93	9.93	9.93
4. Discounted Annual Benefits		9.93	9.37	8.84
5. Present Value of Benefits	28.14 Pula			
D. Financial Evaluation:				
1. Net Present Value	3.18 Pula			
2. Internal Rate of Return	40.69 Pct.			
3. Benefit-Cost Ratio	1.13			

Notes:
a. RHC selling price based on BRET Delivered Production Cost

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sensitivity tests has been conducted, this time with no value attached to the opportunity cost of extra cooking time, but with allowance for varying rates of utilisation of the retained heat cooker. In these tests, the economics of the retained heat cooker turn critically on whether the technology is used at least fifty percent of the time for fuelwood prices ranging from 3 to 5 thebe per kg, even when one has allowed for a five percent annual rate of increase in the real price of fuelwood. Taken together, what the tests in Table XV and XVI indicate is that in order for the retained heat cooker to be economic, fuelwood must be valued at least at 3 thebe per kg, the technology must be used at least fifty percent of the time, and that there must be a relatively insignificant value attached to the opportunity cost of extra cooking time.

Since the retained heat cooker is quite sensitive to a few key assumptions, some attention should be given to potential sources of bias in the analysis. On the cost side, mention has already been made of the difficulty in measuring the life cycle costs of the retained heat cooker. Although relatively liberal assumptions regarding replacement rates have been used, because data on the frequency of use are not yet available, the lifetime of the retained heat cooker could differ significantly from the assumptions employed here. The direction of bias in this case may be to underestimate costs.

Another potential source of bias in retained heat cooker costs is the valuation of insulation materials. In the present analysis, insulation materials are based on imported polystyrene beads imported from South Africa. BRET staff have experimented with less expensive insulation materials, with the result that production unit costs may be overestimated if largely local materials are used.

On the benefits side, two potential sources of bias are household safety and environmental protection. As in the case of BRET stoves, retained heat cookers do provide some protection from the hazards of open fire cooking. However, depending on the insulation materials used, they may also pose a risk in terms of potential spontaneous combustion. Because of limited user experience, it has not been possible to determine whether the benefits of protection from open fire cooking are offset by the risk of spontaneous combustion, with the result that the potential direction of bias in this case is indeterminate. As to environmental protection, to the extent that retained heat cookers conserve fuelwood energy, they provide a benefit to society at large, a factor that should be considered in the context of an <u>economic analysis</u> of retained heat cookers. However, because of the diffuse nature of this social benefit, no attempt has been made to incorporate it into the analysis, with the result that the benefits of the retained heat cooker may be underestimated.

Given the economics of the retained heat cooker, because the BRET cheaper model still costs almost P12.00, the primary market for this technology is likely to be in urban areas. As in the case of the BRET stove, there are some 60,000 urban households that comprise the potential market for retained heat cookers. While the growth of this market is expected to be substantial over the next six years, without more information on how retained heat cookers would be used by Batswana households, it is not clear that this technology would qualify for continued public support. However, since there are potential energy savings on the order of fifteen percent of household consumption, a modest program of continuing research and development on the economics of this technology should be investigated.

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APPENDIX E

RHC Data Sheets

RETAINED HEAT COOKERS: HOUSEHOLD VISITS

Village_____ Date_____ Name of User_____

Interviewer_____ No. in Household_____

FIRST VISIT ONLY: What Interested you in the wonderbox?_____

What convinced you to try it?_____

ALL VISITS:

1. Since my last visit, how many times did you use the wonderbox? _____

Foods Cooked	No. of People Cooked For	Quality/Taste of Food	Problems Encountered

2. How does you family like the food that's been cooked in the wonderbox?

3. What foods have you prepared that they haven't liked?

4.

Foods that cannot be cooked in a wonderbox	Reasons

5.

Preferred foods to cook in a wonderbox	Reasons

6. What do you do while waiting for the food in the wonderbox?

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7. What do you like most about the wonderbox? (Rank order these, 1,2,3, etc)

Likes	Rank
Saves Wood	
Saves Time	
Can do other things	
Prevents Fire accidents	

8. What do you dislike most about the wonderbox? (Rank order these)

Dislikes	Rank
Cannot watch the pot	
Food is not nice	
It is hard to store	
Food spills	
Children/other look in the box	

9. Where do you store the wonderbox? _____

10. How do you keep the pillows clean? _____

_____

11. Have any of your friends or neighbors become curious about the wonderbox?
If yes, how many_____

What did they say about the wonderbox?

12. What questions do you have about using the wonderbox? (Record questions, and answer them)

13. Are there any problems you're having with the wonderbox?
(Record problems and try to propose solutions)

LAST VISIT:
Are you interested in buying a wonderbox? Yes____ No____
Are you interested in making one?Yes_____ No____

What will interest others in using one? _____

Are there poeple who might make a wonderbox to sell? Yes___ No____
If yes, who are they?_____

Note: Remind users of date & time & place of group meeting.

RETAINED HEAT COOKERS: WONDERBOX FOLLOW-UP QUESTIONNAIRE

Village_____ Date_____ Name of User_____

No. in Household_____

What Interested you in the wonderbox?_____

What convinced you to try it?_____

1. Since you've had it , how many times did you use the wonderbox? _____

Foods Cooked	No. of People Cooked For	Quality/Taste of Food	Problems Encountered

2. How does you family like the food that's been cooked in the wonderbox?

3. What foods have you prepared that they haven't liked?

4.

Foods that cannot be cooked in a wonderbox	Reasons

5.

Preferred foods to cook in a wonderbox	Reasons

6. What do you do while waiting for the food in the wonderbox?

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7. What do you like most about the wonderbox? (Rank order these, 1,2,3, etc)

Likes	Rank
Saves Wood	
Saves Time	
Can do other things	
Prevents Fire accidents	

8. What do you dislike most about the wonderbox? (Rank order these)

Dislikes	Rank
Cannot watch the pot	
Food is not nice	
It is hard to store	
Food spills	
Children/other look in the box	

9. Where do you store the wonderbox?_____

10. How do you keep the pillows clean? _____

_____

11. Have any of your friends or neighbors become curious about the wonderbox?
If yes, how many_____

What did they say about the wonderbox?

12. What questions do you have about using the wonderbox?

13. Are there any problems you're having with the wonderbox?

Are you interested in buying a wonderbox? Yes____ No____
Are you interested in making one?Yes_____ No____

What will interest others in using one? _____

Are there poeple who might make a wonderbox to sell? Yes___ No____
If yes, who are they?_____

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APPENDIX F

List of Current RHC Users in Botswana

Ditshegwane Village

Kegakgametse Bathobasele, BRET village facilitator
Grace Matshware, Ditshegwane Bar and Bottle Store
B. Thonkga, Ditshegwane Health Post, enrolled nurse
O. Tshaila, primary school head teacher

Shoshong Village

Senkgopile Kabafitlhetse
Mmoko Kefhilwe
G. Kgamane
Morafi Mokibe
Ketsayang Mokongwa
Reboje Monageng
Gaenkgathe Mosomodi
Babostwamang Mphetolang
Baikanne Mphoyakgosi
Garelakane Nosaakane
Motswamasimo Sebina
Baitsemang Setso
Village Health Committee members, c/o B. Mphoyakgosi

Mahalapye and Serowe-Papapye Subdistricts

Participants in workshop for extension workers:

Eunice Baipoledi
O. P. Baitshepi
Tlhalefang Bareki
Galefiwe Batshedi
M. T. Batshedi
Neo Bogopa
Monica Busang
Sylvester Buzwani
B. Dladia
O. S. Gabasiane
Batshani Gaseitsewe
Kaone Kabelo
M. Kenanao
G. B. Kgamane
G. Koko
G. Koobatile
K. Larona Koobatile
L. Kwelagobe

W. P. Lesaba
D. E. Lopang
D. D. Makwati
Mary Malekane
B. X. Mafalala
M. Mafunda
L. Malatsi
S. B. Mapogo
V. J. Mapogo
Julia Masima
O. K. Menyatso
Gaone Moalafhi
Molelo Molelo
K. Molepo
Unangoni Moloi
Sarah Mosinyi
Bonolo Mothibi
Kgopolo Mothulatshipi
P. Motshotshobo
Sarah Ngwenya
M. Nkoloi
Maria Nkhori
C. B. Noge
M. Nonyane
Gladys Nthobatsang
Moikgatlho Nyatseng
A. Phelelo
Ambrosia Pusi
Keagopole Radibaga
G. Ramoleele
A. M. Samuel
K. S. Seboloko
E. P. Segaise
K. Setlhomo
N. Tamocha
G. M. Tanyala
D. M. Zamba