Evaluation of Recycled Plastic Feedstocks & Marketing Strategies For A Solar Oven

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RECYCLING TECHNOLOGY ASSISTANCE PARTNERSHIP
ReTAP

Evaluation of Recycled Plastic Feedstocks & Marketing Strategies For A Solar Oven

FINAL

Prepared for:

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?? Persons Helping People (PHP) for participating in this project and eagerly working to incorporate recycled plastic into their solar oven products. PHP is a non profit corporation based in St. Paul, Minnesota. The mission of PHP is to empower people and build communities through the support of sustainable and replaceable entrepreneurial activities that utilize appropriate technologies. PHP was established in 1991 using a trust fund donated by Virginia Persons.

?? BottomLine Consulting, Inc., (Ohio) provided invaluable expertise and analysis of the viability of the recycled plastics in the product.

?? Spirit West Management provided a market analysis and perspective for the solar oven.

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INTRODUCTION

Persons Helping People (PHP) is a non-profit corporation whose underlying mission is to help alleviate hunger in developing countries by helping people help themselves.

Their primary product is a prototype solar cooker oven. Solar ovens have the potential to reduce the consumption of cooking fuels, such as wood, by 50%, and have the potential for impacting conservation efforts in developing countries. Over two billion people in developing countries do not have enough fuel to cook their small amounts of rice, corn or beans. Many families spend as much (or more) on charcoal and firewood as they do on food. Others spend up to six or seven hours daily gathering firewood, which is scarce, for cooking. These cooking fires produce irritating smoke. An alternative to cooking over a fire is to use solar ovens. These solar ovens do not create pollution and most fuel-poor countries are sun-rich and can benefit from solar cookers.

PHP gained considerable experience in the manufacture and distribution of solar ovens that were produced by the Sunstove Corporation in South Africa. Sunstoves were sold in Nicaragua, Haiti, El Salvador, Mexico, and Honduras. The experience and expertise gained during this project led PHP to develop a prototype solar oven model, the "SOS Sport." The material cost per oven is projected to remain under $20 (U.S.) and each oven could potentially consume the equivalent of sixty-five, 20-ounce, clear polyethylene terepthalate (PET) bottles, one salvaged aluminum printing plate, and several feet of recycled plastic lumber.

Key elements of a quality solar oven are durability, efficiency, attractiveness, and low-cost. The prototype "SOS Sport" is a low-cost, easily assembled, lightweight, durable, attractive, and efficient solar oven. Although solar ovens will not totally replace other methods of cooking, they have the potential to reduce the consumption of cooking fuels (such as wood) by 50%. This reduction in fuel usage is particularly important in developing countries.

The design of PHP's prototype solar oven, includes four potential components that could be manufactured from recycled plastic; an injection molded casing, the collar, a thermoformed acrylic glazing, and the rigid oven frame. The glazing is bonded to an oriented polyester film to create an insulating air space above the solar oven. The casing and collar pieces are currently manufactured from polypropylene and nylon resins. The lid frame is constructed from natural lumber. Although natural lumber is suitably rigid for this application, it is relatively expensive, generates considerable sawdust during fabrication, has limited weatherability, and is prone to use as firewood in underdeveloped countries.

The CWC worked with PHP and two consultants to evaluate the "SOS Sport" solar oven model with respect to:

?? Use of recycled PET in the collar and casing of the oven;
?? Use of recycled plastic lumber in the framing of the oven; and
?? Marketing strategies.

The estimated maximum temperature inside a solar oven is 300°F, so internal components must withstand exposures to this temperature for extended time periods and service life. The objectives of this project were to: (1) verify whether product performance requirements can be met subsequent to substituting post-consumer polyethylene terephthalate (PET) for the oven collar and casing; (2) evaluate the performance and viability of plastic lumber for the oven frame; and (3) determine appropriate domestic and international marketing strategies for the current solar oven model.

PHP retained the services of Bottom Line Consulting, Inc. (BLC), of Lake Barrington, Illinois, to provide technical assistance for evaluating and testing recycled PET plastic for use in the casing and collar of the solar oven, and for evaluating and testing the use of recycled HDPE plastic lumber for the framing. In addition, BLC served as the technical consultant to two PHP manufacturers during the development of process conditions to maximize material properties for pre-production test runs. Section I describes the evaluation of recycled plastic materials for use in the product components.

CWC retained the services of Spiritwest Management, of Seattle, Washington, to evaluate PHP's current marketing strategy for this product, based on the anticipated use of recycled content components and PHP's long-term business goals. Subsequent to this analysis, PHP decided to produce ovens as a not-for-profit entity, with a major focus on being cost-effective. Section II describes the marketing strategy evaluation and recommendations from Spirit West, as well as the plans and market perspectives that PHP has gained over the years.

I. RECYCLED PLASTIC MATERIAL EVALUATION

1.0 PRODUCT DESIGN OVERVIEW

The solar oven model, the “SOS Sport”, is designed to be a low-cost, easily assembled, lightweight, durable, and efficient oven. It is comprised of an exterior shell, an inner liner forming an oven cavity, and an insulation barrier between the inner liner and exterior shell. The oven cavity is covered with a clear glazing. When the sun penetrates the glazing, dark colors on the exterior of cooking pots and the floor of the oven cavity will transform the light rays into heat. The glazing and insulation hinder the longer heat rays from escaping the oven cavity. The current oven design has a recycled polypropylene plastic exterior casing and collar, and aluminum plates for the inner liner. The unit has a foam insulation layer and a double-glazed lid. The rigid exterior frame is constructed of natural lumber.

Performance Requirements

Bottom Line Consulting, Inc. (BLC) evaluated the suitability of using post-consumer PET, including specification of the particular grade and formulation required, based on performance standards for each component. Solar oven performance requirements are established by the operating conditions and environment in which this solar oven is used.

The performance requirements for the oven and the various components are categorized and presented below. Table 1 provides the performance requirements for the applicable oven components for stiffness, heat deflection temperature and aesthetics. The remaining specifications are presented in Table 2.

?? Stiffness

?? Heat deflection temperature (an indicator of the maximum operating temperature at which the plastic can perform and not degrade)

?? Aesthetics

?? Impact resistance

?? UV Resistance

?? Chemical Resistance

?? Moisture Resistance

?? Shipping Durability

?? Durability

Table 1 Oven Performance Requirements for Stiffness, Heat Deflection Temperature and Aesthetics

Oven Component	**Requirement**		
	Stiffness of Flex Modulus	**Heat Deflection Temperature** (Assumed load of 66 pounds per square inch)	**Aesthetics**
Casing:	Stiffer than the current prototype (made from a different virgin resin) which has a flex modulus of 175,000 psi, preferably a minimum of 375,000 psi.	Must withstand maximum ambient heat of about 125? - 130?F, preferably about 170°F.	As clear as possible but UV efficient.
***Collar**:*	650,000 – 800,000 psi; Cannot warp in hot sun, exposure typical of Nicaragua-type climate. Determined by HDT specification of greater than 300 °F	Must withstand high oven temperatures, up to 300?F or higher.	Black with matte finish preferred. External texturing desirable to minimize appearance of scratches, etc.
***Glazing**:*	Must not bow at cooking temperatures of up to 300°F.	Must withstand temperature of 300?F (although it is exposed to temperature lower than 300 ?F due to the air space between it and the protective PET film).	Black with matte finish preferred. External texturing desirable to minimize appearance of scratches, etc.
Framing:	Minimum of 200,000 psi. Unfilled HDPE plastic lumber will generally be about 265,000 psi. It cannot compete with wood on a strength basis -- the stiffness of most wood is at least 1,000,000 psi.	Not applicable.	Not applicable.

Table 2

Oven Performance Requirements for Impact Resistance, UV Resistance, Chemical Resistance, Moisture Resistance, Shipping Durability and Service Life

Performance Measure	Discussion of Requirement
Impact Resistance	Minimum standard for drop impact strength: 6 feet, or 100 foot pounds, applied to a test unit comprised of the solar oven containing two eight-pound weights simulating the weight of two pots containing food or water. This impact should result in no breakage, particularly at the outer edges of casing.
UV Resistance	Ten-year life under UV exposure for oven and components.
Chemical and Moisture Resistance	The plastic components typically are not directly in contact with food or oils. However, the oven should be mildew resistant for environments where ambient temperatures are constantly above 60?F.
Shipping Durability	During shipping, casings are nested upside down and rub/vibrate against one another. Shipping must not cause damage or scratches.
Service Life	Usage of three to four times per week for four to six hours (or 620 to 1250 hours per year) for 10 years.

2.0 SUITABILITY OF POST-CONSUMER PET FOR USE IN SOLAR OVEN COLLAR, CASING, AND GLAZING

BottomLine Consulting, Inc. (BLC) reviewed two comprehensive papers on solar ovens, which provided important background information on solar cooking and ovens[1]. Potential grades of post-consumer resins were identified that would produce solar oven components meeting the performance requirements of Section 1.1, be cost-effective, and compatible with standard plastic manufacturing equipment.

CASING: Unmodified post-consumer PET for the casing will meet all but one of the performance requirements; the drop impact strength requirement of 100 ft-lb. The casing on the oven will primarily absorb any impact. To ensure the proper toughness over the service life of the solar oven, a small percentage of impact modifier must be added to the PET formulation.

COLLAR: During operation, a portion of the collar piece is subjected to high temperature (up to 300?F) and humidity. Due to the low glass transition temperature of unmodified post-consumer PET, at 170?F, PET is unsuitable for this application. However, glass-filled grades of post-consumer PET are available for high heat applications. At 15% glass content, these grades are thermally stable up to 400?F. Such a material is suitable for the solar oven collar piece.

GLAZING: The glazing must transmit visible and near infrared wavelengths without discoloration and withstand the relatively high temperatures (up to 300?F). The current design, consisting of acrylic sheet bonded at the perimeter to polyester film, has performed extremely well. A 10-millimeter air space between the bubble of acrylic and flat film provided excellent insulation across the glazing surface. The acrylic sheet thickness of 0.093 inches provided a good

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[1] Funk, Paul. Analysis of a Solar Box Cooker for East Africa – A Thesis Submitted to the Faculty of the Graduate School of the University of Minnesota in partial fulfillment of the requirements for the Degree of Master of Science, December 1992.

Funk, Paul. Parametric Model of a Solar Cooker for International Development A Dissertation Submitted to the Faculty of the Department of Agricultural and Biosystems Engineering in partial fulfillment of the requirements for the Degree of Doctor of Philosophy in the Graduate College of the University of Arizona, April 1996Model of a Solar Cooker Funk Paul, et al. “International Standards for Testing Solar Cookers” balance of strength and rigidity. The only problem that has occurred with this component is sagging and clouding of the acrylic when used alone. This issue can be corrected by incorporating an acrylic that has higher heat resistance, or by improving the design of the double-wall glazing. Based on the stringent performance requirements for the glazing, no further analysis was conducted for conversion to use of a recycled plastic in this component.

2.1 Determination of Process Limitations and Solutions

A working relationship was established by PHP with two plastic manufacturers in Minnesota who produce injection molded plastic products. Both have manufactured the prototype casings and collars for the current PHP oven model. BottomLine Consulting contacted key personnel at both plants to determine their processing capabilities, and to evaluate the feasibility of running recycled PET in their existing equipment. Discussions included a detailed review of drying, blending, material handling, grinding, weight feeding, molding, and tooling operations.

One facility lacked adequate drying equipment for running post-consumer PET. This facility primarily molds polyethylene and polypropylene, neither of which is dried prior to molding. PET is extremely hygroscopic and wet resin degrades rapidly at normal molding temperatures. Therefore, inadequate drying results in inferior properties, such as reduced impact strength, and increases molding problems such as drooling, sticking, flashing, and splay. The company borrowed a desiccant dryer from another nearby plastic manufacturer to run the PET test product trials. PET pellets were used, rather than PET regrind, since pellets have much lower moisture than regrind, and can be adequately dried in a desiccant drier. (A crystallizing dryer is typically recommended for PET regrind.)

Although not a limiting factor with respect to the testing, both molding machines available for the casing and collar molding trials were oversized, i.e., shot capacities were above the desirable ratio of 2:1 to 3:1 of part weight. This exposes the melted resin to long residence times in the machine barrel, thereby diminishing material properties. This potential performance-degrading factor was noted as the trials proceeded.

2.2 Formulation Development

Successful molding of post-consumer PET requires tailoring the resin chemistry and molding conditions to meet the performance properties at the lowest possible piece-part cost. Given the performance requirements established above, BLC developed the most cost-effective formulations for the solar oven casing and collar.

CASING

The target for incorporation of recycled PET (RPET) in the casing was to enhance performance while using a recycled feedstock. The key performance properties for the casing are:

Stiffness of Flex Modulus	>375,000 psi
Drop Impact Strength	100 foot-pounds
HDT at 66 psi	>130 degrees F, preferably about 170 degrees F

RPET has limited impact strength for injection-molded parts. An impact-modified grade of post-consumer PET from beverage bottles was used to meet the casing performance specifications. Carbon black was added to provide ultraviolet light stability for the casing. The recommended blend of RPET and additives must be desiccant dried and kept bone dry until molding, otherwise degradation from hydrolysis will occur. This type of degradation can result in brittle parts, altered melt viscosity, and changes in mechanical properties.

The injection mold previously used for the casing was intended for a different resin, and did not hold up to a production run using the post-consumer PET. A new mold is required to be able to utilize recycled PET in the casing.

In order to optimize the production run for the casing, settings were recommended for the melt temperature, nozzle temperature, increasing temperature profile, mold temperature and injection speed.

COLLAR

The target for incorporation of recycled PET (RPET) in the collar was to enhance the stiffness, UV resistance, dimensional stability, and heat resistance, while using a recycled feedstock. The key performance properties for the collar are:

?? Stiffness of Flex Modulus	>650,000 – 800,000 psi
?? HDT at 66 psi	>300°F
?? Embrittlement	Non-significant over 10-year life

A glass reinforcement additive is required in the RPET blend, at a specific concentration, for this part to provide heat stability during the cooking step, and dimensional stability upon exposure to ultraviolet heat. Carbon black was also specified to provide ultraviolet light stability.

As with the casing, the recommended blend of RPET and additives must be desiccant dried and kept bone dry until molding, otherwise degradation from hydrolysis will occur. Settings for the melt temperature, increasing temperature profile, mold temperature and injection speed were recommended for optimizing the production run for the collar.

GLAZING

Due to the outstanding weatherability, clarity, and UV transmittance properties of the existing acrylic sheet/PET film glazing, no new formulations were developed. Impact-modified acrylic is superior to all other clear plastic materials as the primary glazing component.

2.3 Evaluation of Production Runs

CASING

The initial solar oven casing trial was not successful, primarily due to mold problems. To reduce cost, the existing casing mold was built from several small pieces of steel. The higher viscosity and pressures used to mold an engineering resin, such as post-consumer PET, were too great for this mold. Although a few short casing parts were produced and were quite tough, the resin began to stick in the mold seams on the female sides where cooling efficiency is poor. The sections of steel on the male side began to shift and caused a blockage in flow of the resin. This resulted in higher pressures and more separation of the mold sections. Several attempts to repair the problem failed and the poor construction of the mold was too much to overcome.

A new casing mold is currently being designed and tested because the prototype mold was not strong enough for the required pressures of recycled PET. (The results of this development and initial production trials will be included in a future version of this report).

COLLAR

The collar piece requires good heat resistance, and therefore a formulation containing recycled PET and a glass filler was developed for the collar piece.

The initial collar production run successfully produced good collar parts by the sixth shot, and commercial cycles of 45-50 seconds were reached by approximately the twentieth part. The collar stiffness of the flex modulus (at room temperature) was about 930,000 psi, exceeding the initial performance requirement.

Two problems became apparent during the production run:

?? one side of the collar piece filled sooner and was thicker due to a flow imbalance (the earlier feedstock also exhibited this problem); and

?? the finished parts were somewhat brittle.

Correcting the misalignment between the mold cavity and core could alleviate the flow imbalance problem. The brittleness was primarily due to the low intrinsic viscosity of the Plenco resin, coupled with the relatively long residence time of the resin in the 60-ounce machine. As noted in Section 2.1, exposure of the melted resin to long residence times in the machine barrel will result in a degradation of material properties.

3.0 RECOMMENDATIONS FOR RPET USE IN COLLAR AND CASING

This project demonstrated the feasibility of using post-consumer PET in the collar and casing of PHP's box-style solar oven. The impact-modified RPET formulation developed for the casing and glass-filled formulation developed for the collar piece, represent the most cost-effective resins meeting PHP's performance specifications.

BLC recommended the following priority actions for PHP to ensure successful commercialization:

1) Purchase a medium-to-high production mold for the solar oven casing with an initial nominal wall thickness of 0.075 inches. This mold will be manufactured from a single piece cavity and core and designed to produce high quality parts from an engineering resin, such as post-consumer PET.

2) Complete the casing production trial to confirm that the tool has been properly made; fine-tune the nominal wall thickness; and determine the exact level of impact modifier additive. Use the formulations and process conditions established for casing production.

3) Run the collar production trial again with the realigned tool so that the part fills equally on each long side. Use RPET with an intrinsic viscosity (IV) of 0.60 or greater. A specific manufacturer and resin was identified.

4) Continue using the double-wall glazing of impact-modified cast acrylic sheet/PET film with the minimal air space of 10 millimeters or 0.393 inches. The air space is critical to efficient solar oven operation and, just as importantly, protects the acrylic from reaching temperatures above 170?F where it will soften, sag, and/or craze. The domed portion of the glazing should be slightly larger than the inside dimensions of the collar.

The implementation of these recommendations will result in the production of high quality PHP solar ovens. Each solar oven will consume the equivalent of sixty-five, 20-ounce post-consumer PET bottles.

4.0 RECYCLED HDPE PLASTIC LUMBER IN SOLAR OVEN GLAZING FRAME

BottomLine Consulting completed a feasibility analysis on the use of composite plastic lumber for the glazing frame on certain models of PHP's solar oven. Natural lumber is currently being used for this rigid frame, but it is relatively expensive, generates considerable sawdust when fabricated, has limited weatherability, and is subject to use as firewood in undeveloped countries.

Plastic lumber is extremely durable and maintenance-free. It is resistant to the environment, especially to mold, insects, warping, rotting, splintering, discoloration, and ultraviolet light. Given the proper formulation, plastic lumber will have a twenty-year life in an aggressive high-temperature, high-humidity environment.

The primary downsides to using composite plastic lumber are potential high cost, poor thermal stability at solar oven operating temperatures, and fabrication problems. This project carefully assessed the benefits and disadvantages of converting the glazing frame from natural lumber to plastic lumber.

4.1 Performance and Fabrication Needs

BottomLine Consulting reviewed with PHP the product's performance requirements and fabrication needs for use in solar ovens. The goal was to develop a glazing frame that is attractive, stiff, heat resistant, dimensionally stable, safe, ultraviolet (UV) light resistant and have high weatherability. From a fabrication standpoint, the frame material must be easy to cut and assemble with simple tools and the process must generate minimal waste.

4.2 Specifications

The growth and maturity of the plastic lumber industry during the 1990s has established this synthetic product as a viable alternative to natural and/or treated lumber. Early versions of plastic lumber were manufactured from mixed recycled plastics. As a result, the properties of these products varied from batch to batch, limiting their use to low valued, non-critical applications. The majority of plastic lumber produced today is based on a high percentage of post-consumer high density polyethylene (HDPE). Various additives, modifiers, and other resins are used to tailor properties to product specifications. Technical data sheets on plastic lumber products and grades can be acquired from the product manufacturers and many are available on line[2].

The initial task for PHP in this project phase was to establish product specifications for the glazing frame and solicit bids from lumber producers who could meet these requirements. The following technical specifications were developed:

?? Stiff in long sections – flexural modulus > 200,000 psi
?? Heat resistant – heat deflection temperature of 300?F

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2 Trex™ - Wood-polymer composite containing recycled polyethylene film plastic, by Trex Company, Winchester, VA. (URL: http://www.trex.com/)
Durawood™ – Plastic lumber made from recycled, purified HDPE, by Eaglebrook Products, Inc. Chicago, Illinois. (URLhttp://www.eaglebrook.com/)
EcoBoard® - Plastic lumber made from 100% recycled polyethylene, by American Ecoboard Inc., Farmingdale, NY. (URL: http://www.ecoboard.cc)

?? Dimensionally stable – thermal expansion < 5.0 x 10-5 inch/inch/?F
?? Safe – splinter-free and chemically inert
?? Ultraviolet Light stable – maintain 75% tensile strength for 10 years
?? Weather resistant – no rotting, warping, splitting, and minimal color shift
?? Attractive product – wood grain finish yet long-lasting

The synthetic lumber also must be amenable to easy assembly without generation of waste materials, such as sawdust.

4.3 Performance Requirements and Potential Suppliers

Eaglebrook Plastics in Chicago, now part of USPL (the U. S. Plastic Lumber, Ltd.) and American Ecoboard in Farmingdale, NY, were contacted as potential suppliers of high quality plastic lumber for the PHP glazing frame. Both companies have developed the specialized grades of plastic lumber that are required for PHP's solar oven. Both also indicated a high level of interest in supplying product to PHP.

The most difficult specification to meet for the PHP glazing frame is the thermal stability requirement of 300?F. This temperature is higher than the melting point of the structural resin in plastic lumber (recycled high density polyethylene from post-consumer milk bottles).

A glazing frame made from glass-reinforced high-density polyethylene (HDPE) lumber would meet all the above glazing frame specifications, except for thermal stability. Once its surface temperature reaches 265?F, the glass-reinforced HDPE will begin to distort and lose properties; HDPE's service temperature cannot be increased to 300?F because of its melting point limitation. Several other plastic lumber material and processing options were considered to meet PHP's technical specifications. These included co-extrusion of a high-heat material on the exterior surface, spray or dip coating of a high-heat material, or non-HDPE plastic lumber. The first two options were eliminated from further consideration because of high cost and/or technical limitations.

The use of a non-polyethylene structural resin received serious consideration for PHP's glazing frame. From a cost standpoint, the obvious choice would be polypropylene. Homopolymer grades, such as those used in the fiber industry, could be formulated with fillers and/or glass to meet PHP's specifications. Unfortunately, polypropylene recycling is not well developed at this time. As a result, the cost of this option is estimated to be 25% – 40% above HDPE-based plastic lumber.

Through BLC's industry network, an emerging development came to PHP's attention as a future consideration. The carpet industry has undertaken several initiatives to recycle used carpeting, about 75% of which is nylon. A recent market development project completed by R. W. Beck, a solid waste consulting company, has identified several potential products that could be made from carpet waste. Nylon-based plastic lumber was one of these products. Properly formulated, nylon-based lumber would meet PHP's specifications. Although not commercialized at this time, these developments represent an encouraging possibility for future use in solar ovens.

4.4 Cost Analysis of an HDPE Plastic Lumber Glazing Frame

Although it was determined that HDPE plastic lumber would not meet the solar oven's performance requirement of a 300?F service temperature (due to HDPE's intrinsic melting point limitation of 265?F), a cost analysis was performed to compare glass-reinforced HDPE plastic lumber and natural lumber. This analysis was based on the existing dimensions of the glazing frame, which are as follows:

?? Top and bottom – 24 ¾" long x 1 ½" wide x 5/8" thick
?? Sides – 16 3/8" x 1 ½" x 5/8" thick
?? Corners are mitered at 45?
?? Channels are routed on inside edge of frame to hold glazing

Based on verbal quotes from USPL and American Ecoboard, glass-reinforced HDPE lumber meeting these width and thickness dimensions would cost 50-55 cents per linear foot in small quantities (100 linear feet total order) and about 40 cents per linear foot in bulk (1999 price quotes). In addition, American Ecoboard has indicated they could modify an existing extrusion die so that the glazing channels are integrated into the profile, thus eliminating the manual routing step.

Given that about seven-linear feet is required for the current solar oven design, the HDPE lumber frame would cost about $3.75 per solar oven in small quantities and $2.80 per solar oven in production quantities (per 1999 lumber quotes). PHP indicated that the production quantity cost could be absorbed and represents a small cost savings over the natural lumber frame. The elimination of the messy routing step represents a significant labor savings, and minimizes waste disposal costs associated with sawdust. The fabrication process would also be simplified, and would only require mitering and assembly of the frame around the glazing.

5.0 RECOMMENDATIONS FOR RECYCLED HDPE PLASTIC LUMBER IN SOLAR OVEN GLAZING FRAME

Based on BLC's analysis of the cost and performance of various types of composite plastic lumber, and PHP's specifications for the glazing frame, BLC recommends that PHP pursue the option of glass-reinforced HDPE lumber. The 265?F service temperature limit for HDPE should be adequate for most applications. Samples of glass-reinforced HDPE lumber are being shipped to BLC so that an assembled frame can be field-tested. Assuming a positive test, this is PHP's lowest cost option.

Alternative plastic lumber materials, polypropylene and nylon, have been identified as future options for the PHP glazing frame. The viability of these options is contingent upon improved infrastructure for collection and reprocessing of polypropylene fibers and nylon carpeting.

II. MARKETING STRATEGY EVALUATION

1.0 INTRODUCTION

The "SOS Sport" solar oven has been developed with the intent to be an environmentally sound product that raises living standards by replacing the cost of cooking fuel with free solar energy, and reducing deforestation. PHP steadfastly holds to the mission of providing some form of assistance to people or communities, but had at one time considered creating a for-profit subsidiary to market, manufacture, and distribute "SOS Sport" in domestic and international markets. Successful integration of non-profit and for-profit objectives is somewhat complex. PHP subsequently decided to remain a not-for-profit venture for oven production, primarily because businesses and individuals are quicker to provide ideas, contributions and price breaks for materials to not-for-profit companies.

2.0 CURRENT MARKET CONDITIONS

PHP clarifies that the market research by Spirit West Management, Inc., as stated below, includes the often assumed and relayed assumptions regarding challenges of acceptance of solar cookers by citizens in developing countries. PHP believes this reflects the generalized scenarios of lack of availability of low-cost, aesthetically pleasing, durable, effective, solar cookers. As such, they have supplemented this marketing analysis with their real world experiences in marketing their solar oven. These comments are included in italics.

The two primary markets that PHP seeks for their solar ovens are: developing countries, and the domestic United States. The domestic solar oven market saw small gains leading up to the year 2000. Retailers and manufacturers predicted a decline in this trend after January 2000, although the trend has not been monitored since issuance of this report. Before the millennium survivalist trend, most retailers would sell between two and three solar ovens per month, generally to those people interested in the concept of solar cooking.

Current domestic market trends for solar ovens appear to be weak, therefore better results are likely to be obtained by targeting the international marketplace. One of the most significant barriers appears to be the initial resistance to the use of solar ovens in developing countries because it changes the traditional cooking process. Also, additional funds are required for education on the use of solar ovens and “technology transfer” of the oven.

There is a small market for solar ovens in the recreational equipment field. Due to their bulk and lack of usability in an "on the go" environment, backpackers typically do not want to carry them, and campers want their food cooked quickly and may not want to leave food out cooking in an unattended camp.

There is often an initial resistance to using solar ovens in developing countries because it changes the way people cook their food. Wood gathering is often a tribal custom done in groups and is enjoyed by the community. Solar ovens would eliminate the need for wood gathering. Traditional cooking over wood fires is typically completed in under an hour, while solar cooking may take from two to eight hours. In specific cases where the use of solar ovens was successfully adopted, the market was not economically sustainable on its own; rather, non-profit economic development and/or educational programs supplemented the market.

This initial resistance is present in some developing countries. However, there is less resistance once basic awareness training on issues of air quality, inaccessibility and cost of fuel, water pasteurization, etc., are presented. There is also the issue concerning the availability of cookers and/or supplies to make solar cookers from materials available in developing countries.

Based on PHP’s experiences in several countries, there is an interest in solar ovens to be used as a partial solution to decrease consumption of fossil fuels; improve food nutrition; reduce disease and burns; improve air quality while cooking; enhance family budgets from fuel savings; and eliminate water borne bacteria by water pasteurization in the solar ovens. Some families may even desire multiple ovens.

3.0 MARKETING STRATEGY RECOMMENDATIONS

Considering PHP's business objectives, Spirtwest found two organizations that might provide a business model. Both organizations are extremely successful in their main objective to provide useful assistance to people who need it; one company is for-profit, one is not for profit.

The for-profit company develops useful devices that work without electricity (e.g., radios that are powered by a winding mechanism). Their mission is to hire a variety of people, educated and non-educated (from prisons, welfare systems, etc.) and train them to work on the production line to build these devices. They have found distribution outlets for these devices around the world and especially in third world countries.

The non-profit organization develops documentaries depicting the stories of the people they assist. The documentaries are shown in cross-promotion with celebrity events that raise substantial sums of money for the people they are trying to help. From the proceeds, they develop and implement programs for these people based on their needs. Approximately 98% of the funds that are raised go directly towards helping the people.

Given PHP's current model, Spiritwest proposed that PHP adopt a for-profit strategy, similar to the device company, but remain a non-profit. PHP would then identify distributors in other countries who would be willing to sell their solar ovens. The for-profit device company could be a possible strategic licensing partner for PHP. The device company does not currently market a solar technology but they may be interested in planning future product development, since their niche is alternative energy. This company has resources, credibility, and market connections that PHP does not presently have.

Given that PHP has past experience in the marketing of Sunstoves overseas, it would be advantageous for PHP to explore the possibility of obtaining funds from international economic development organizations, such as US AID, for specific manufacturing, distribution, and implementation projects that would provide the necessary supplemental funds for recruiting and educating users, developing local distribution resources, and implementing solar oven use in identified communities.

Successful economic development projects can also create “free” marketing - media publicity for the “SOS Sport” that would be financed by a participating public agency. This publicity can also help to establish and define a potential market. PHP could license their solar oven technology and allow overseas manufacturers to manufacture and distribute units for a fee, while remaining a non-profit.

4.0 PHP MARKETING PLAN

Persons Helping People decided to operate as a not-for-profit, with a major focus of making the “SOS Sport” available at a low-cost. They are poised to mass-produce the “SOS Sport” at a material cost of $20 and will actively market the solar oven domestically and internationally to developing countries.

The environmental feature of recycled-content components will be emphasized. Each “SOS Sport” utilizes sixty-five 20-ounce recycled plastic soft drink bottles and a salvaged aluminum printing plate.

Persons Helping People plans to focus overseas marketing activities to church groups, international service clubs, relief organizations, major corporations with a presence in developing countries, sponsor-a-child agencies, and similar organizations. The women in developing countries are also a target market group. Women like to use the solar ovens for their families or as a business venture. For overseas markets, PHP expects to ship unassembled oven components, assuming that assembly by buyers or distributors of the ovens at the shipping destination is kept affordable. Conceivably, unassembled parts for 2000 cookers will be shipped in a 40-foot container.

Domestically, market efforts will focus on:

?? Service and humanitarian organizations, schools, churches, individuals, etc., especially to offer the solar ovens as a fundraising product.

?? Environmental education centers, summer camps, gardeners, senior citizens at retirement villages.

?? Mission and relief agencies, churches and others purchasing solar cookers for overseas distribution.

?? Personal use (recreational, beach parties, picnics, desert Southwest, etc.).

The marketing strategy also includes supplying the “SOS Sport” as a fundraiser for interested groups, selling directly through the Internet, and advertising to a current list of more than 400 interested parties. The Solar Oven Society (SOS) maintains an active web page, which should yield additional customers.