>> PROJECT BRIEF

This is part of a series of project briefs discussing the activities, research findings, and field experiences of PATH's Safe Water Project.

SEPTEMBER 2011

Our end-users as co-designers:

Development of the Safe Water Project Reference Design and Design Guidelines

Summary

In 2011, PATH's Safe Water Project (SWP) launched two important tools for increasing access to clean water at the household level: a set of Design Guidelines for an optimized household water treatment and safe storage (HWTS) product and a Reference Design that interprets the Guidelines as a working, manufacturable unit. Both tools were developed with input from users and experts. The Guidelines incorporate existing standards as well as user experience attributes, and the Reference Design was refined through rigorous household testing. The Design Guidelines provide user-focused guidance to support the development of HWTS devices targeting low-resource settings. In addition, PATH and its partners have developed a platform specification for a common filter-to-device interface. New devices based on the Design Guidelines and platform specification should be better suited for low-income families, increase product choice, and reduce cost to low-income consumers.

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The SWP Reference Design and Design Guidelines promote optimized water filter design. Both were developed through a rigorous, participatory, user-centered process.

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A catalyst for global health

Three Chinese manufacturers soon will market products based on the Reference Design and using the common filter-to-device interface. PATH is eager to collaborate with additional manufacturers, and the Guidelines are now available on the web.

Design Guidelines

An extensive, online resource for HWTS manufacturers and designers, with advice on external size, internal capacity, shipping volume, materials, maintenance, and many other factors. Available at: **http://www.path.org/hwts-design-guidelines/index.php**.

Reference Design

A sample, working interpretation of the Design Guidelines. Extensive schematics and construction information are available from PATH.

Background

A billion people without safe water

While most of us take easy access to clean water for granted, nearly one in six people worldwide are not so fortunate and are at risk of disease every time they take a drink, sometimes from diseases that kill.[1] Diarrheal disease alone, much of which is attributed to unsafe water, causes 1.8 million deaths per year. The toll is especially high among children younger than five.[2]

Dual strategies for obtaining clean water have been in place for years—improving water quality at the source (for example, a reservoir or well) and improving quality at the household level—through use of filters or various methods of decontamination. Water treatment and particularly safe storage at the household level are crucial, because even clean source water can be contaminated or re-contaminated by dirty containers or dirty hands when the water is transported or when water is stored and dispensed in the home.[3] Data show that interventions designed to improve water quality at the household level are about twice as effective as those focusing on the source.[4]

Unfortunately, low-income households generally cannot afford existing household water treatment devices. And PATH research has shown that many available products—even when affordable—either do not function well within challenging environments, are not sufficiently attractive to families and do not sell, or cannot be sustainably used over the long term.[5,6]

In 2006, PATH launched the Safe Water Project with funding from the Bill & Melinda Gates Foundation to investigate the potential for market-based approaches to providing clean water for low- and middle-income users, with the ultimate goal of reducing disability, illness, and death related to safe water. The project is designed to work through market mechanisms to increase the effectiveness, appropriateness, and affordability of "household water treatment and storage" (HWTS) products and improve access to and promote correct and consistent use of HWTS products. Our goal is that long after the PATH project is done, commercial enterprises will continue to compete with one another to produce, distribute, sell, and maintain effective, desirable, and affordable HWTS products for lower-income families. (For more information, please visit **http://www.path.org/projects/safe_water.php**.)

To support such manufacturers, the Safe Water Project has focused on the development of globally relevant Design Guidelines for producing high-quality, affordable, appropriate, and accessible HWTS products. The Reference Design—a physical interpretation of the Guidelines—was developed through rigorous, user-centered testing. PATH first assessed existing products and then developed and tested new designs. The resulting Reference Design validated the Design Guidelines and is the foundation for three new HWTS products.

An iterative, user-centered design process

Products cannot be successful unless they respond to user needs and preferences, so user involvement and input are central to the PATH product development process. Understanding and incorporating the perspectives of end-users in the design process helps us develop the most appropriate products—ones that are accessible, affordable, acceptable, and easy to use—which in turn ensures that the products will be used correctly.

To create the Reference Design and the Design Guidelines, the Safe Water Project implemented an iterative process of listening to user ideas and observing user interactions with HWTS products; developing draft guidelines; and then testing, and re-testing, evolving prototypes.

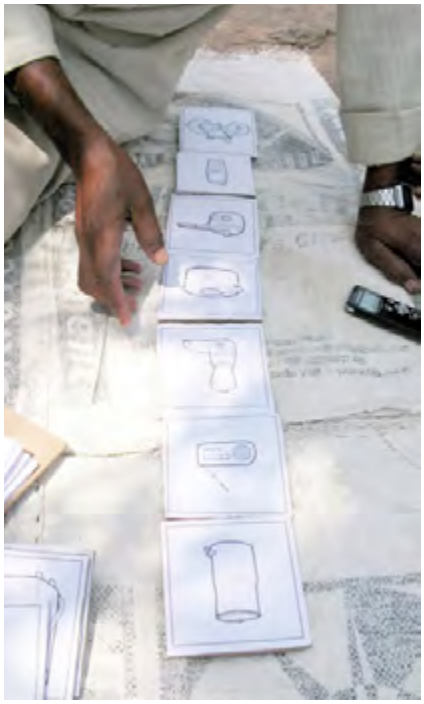
In the original Safe Water Project proposal, PATH planned to assess already existing HWTS products in the market and determine which were most effective and acceptable to users. However, during this early work, it became clear that there was also a real need and opportunities for new and improved technologies and products. Thus, PATH began to focus on bringing more affordable, desirable, and effective products to the market and worked to develop the Design Guidelines for HWTS products. In tandem with the development of the Guidelines, PATH took the step of designing a new HWTS device specifically for low-income users. Grounded in user-research—including feedback on existing products and product concepts as well as observations of actual use—PATH set out to develop an appropriate device. The lessons learned from this process were then used to inform and support the Design Guidelines. As part of the product development process, PATH was especially interested in developing a product platform—a common filter-to-device interface that would ensure that filter elements produced by different manufacturers would fit water filter devices from other companies. Standardization of key elements of the design would foster competition and reduce production costs and cost to consumers. This is PATH's "platform strategy" for HWTS.

The participatory design process began with informal user-testing in 2008. The focus was on understanding user needs and preferences around household products in general, and more specifically, water handling, treatment, and storage—as well as collecting feedback on existing HWTS products. To gain a deeper understanding of low-income user experiences with and preferences for HWTS products, this work was followed by extended user-testing in 2009. Five HWTS products were placed in homes for an extended period of time. From this initial formative work, the team learned that users were hoping for products that would:[5,6]

- Improve water taste.
- Make the water look pure and clean.
- Kill germs.
- Filter sand and dirt.
- "Increase metabolism" (provide healthy water).
- Work for 3 to 4 years without needing repair or breaking down.
- Have an ultimate working life of 5 to 10 years.

Initial user feedback indicated that a gravity-fed, vertical, two-container device might be the most appropriate household water treatment option for these users. However, users were not very happy with any of the commercial units tested, stating that some were:[5,6]

- Too expensive.
- Too fancy ("It is nice, but not appropriate for us" or "It is good for an office, not a home").
- Not fancy enough ("It looks like a rubbish bin").
- Too complicated to assemble, use, clean, or maintain correctly.
- Too easy to use incorrectly, or too inconvenient for sustained use.



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During extended user testing, a card-sort exercise was used to understand how users rank the value of HWTS products against other household goods.

Through the formative user-research process (Figure 1), it became evident that no existing HWTS technology was clearly superior to the others in terms of effectiveness or appeal for the target population of low-income consumers and that it would be necessary to either develop new or redesign existing products to incorporate the best elements of what had been tested while addressing a variety of technical and aesthetic concerns. With the goal of designing an appropriate product that would encourage low- and middle-income families to consistently and correctly treat their water, PATH applied the insights from the initial user feedback to the product design process.

Reference Design prototypes in the field

Work on the Reference Design started in November 2009 and included a systematic review of all the previous user-test data and consultation with an Expert User Group in India. During this period, the team began crafting an early version of the Design Guidelines and created "alpha prototypes"—simple, first draft embodiments—of the Reference Design. The alpha prototypes exhibited traits based on the user feedback about existing HWTS products, but user-testing of the alpha prototypes itself was necessary to test multiple options that could meet user needs.

Alpha prototype evaluations were conducted in one urban and one rural site in Andhra Pradesh, India, in February 2010. Participants included unskilled laborers, homemakers, and agriculture workers. Approximately 40 individuals were brought together

Figure 1. User-testing to production

to look at images and models of several devices and to talk about aesthetic considerations, including color, form, and shape. They also critiqued samples of different types of plastic that could be used to produce the final prototype. Some respondents were asked to work out how to assemble the alpha prototypes in small groups while the Safe Water Project team observed.

Based on user experience and the challenges observed in assembling the alpha prototypes, the alpha test results taught several lessons to the design team:

- The filter element must insert only one way.
- The filter-to-device interface should be easy to understand and use.
- The filter element's handle was difficult to use because it required two hands.
- Participants did not understand how to assemble the pre-filter and found it untidy.
- Participants incorrectly tried to assemble the device by matching parts with like colors.

In response to these observations, PATH developed a filter-to-device common interface (the C1 Common Interface), as part of the Reference Design, which enhances safety and usability. The C1 Common Interface features safeguards to prevent upsidedown installation of filter elements and reduces the likelihood of contaminating the treated water when changing filter elements. The C1 Common Interface also plays a lead role in the implementation of PATH's platform strategy (see "Advantages of PATH's platform strategy" below).

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Urban and rural Indians from low-income households helped test early prototypes.

Using the feedback on the alpha prototypes, PATH focused on a single design direction and by September 2010, had prepared the next iteration—the "beta prototype."

To once again validate the design against user needs and preferences, PATH took the beta prototype to the field. The study team placed a beta unit in each of 15 low-income households in and around Hyderabad, India, for three months of everyday use. Thirteen of the fifteen families had children younger than five. None of the households owned or used water treatment devices at the beginning of the study and all had varying sources of drinking water.

Research questions for the new study focused on assessing:

1. **Whether the prototype was easy to assemble correctly: the "out-of-the-box experience"**

   This involved observing the initial assembly process and gathering perceptions, interactions, and impressions that informed ease of set-up, along with assessing the usability of filling and dispensing the beta device. Observing out-of-the-box use

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The beta prototype was placed in 15 homes in or near Hyderabad, India.

was integral to ensuring that the households were able to assemble the prototype correctly. The team used both time-lapse photography and video to document the process for further design improvement.

2. **Whether or not the beta unit effectively treated water for a sustained period of time.**

   A water quality test was conducted to evaluate how well the device performed in the field. Water quality data were collected three times:

   - After first use (following supervised and correct assembly of the beta device).
   - After one month of use.
   - After two months of use.

3. **Whether the beta unit supported a sustained, appropriate, and desirable user experience**

   The researchers gathered overall feedback on the user experience, including factors such as ease of use, cleaning the unit, replacing the filter element, flow rate, durability, and ease of repair.

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The research team docoumented users assembling, cleaning, and using the beta prototype over a three-month period.

The study exposed fascinating and useful information about user attitudes and how users interacted with the beta design. Overall results were encouraging. PATH worked diligently to design a product that could be assembled only one correct way. This work paid off; participants were able to assemble the device with virtually no demonstration, assistance, or instructions.

The water quality data showed that the device performed well in the field. However, the study also clearly showed that some household use scenarios posed significant challenges: when there was extreme source water contamination, when cleaning and handling were suboptimal, and as the filter element aged. But despite these challenges, the prototypes all met the standard of providing *E. coli*-free water at the end of the study. Participants also enjoyed the taste of the filtered water. One participant even likened the taste of the filtered water to that of coconut water. Most participants believed that their health had improved as a result of using the Reference Design.

Participants reported a positive experience with the Reference Design; they used it without any major difficulties, and were able to clean it effectively. Participants also felt proud to have the unit in their homes, and after three months, reported that they were still using the Reference Design every day. During the home visits, PATH researchers were able to see how water treatment behavior was beginning to shift. Some families reported that they no longer wanted to drink untreated water and brought their own water when visiting a neighbor. Thirteen families with school-age children sent bottles of home-treated water with them to school so that they could avoid drinking untreated water at school.

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Families proudly sent children to school with a bottle of home-filtered water.

Some problems discovered with the test units—like difficulty cleaning certain areas, lack of durability, and contamination at the tap—were artifacts of the prototyping materials. But design problems also were discovered; for example, there were problems with the pre-filter, a cloth sieve placed over the opening of the top container to catch larger objects in the source water. The pre-filter sometimes caused wastage (spilling). These challenges were documented and will be provided as recommendations to be incorporated by future product manufacturers.

Within a few months of beta test completion, the Design Guidelines were finalized and launched on the web at **http://www.path.org/hwts-design-guidelines/index.php**.

Advantages of PATH's platform strategy

The Reference Design is made up of the two interoperable components: (1) the *device*, with upper and lower containers for untreated and treated water, a lid, and a tap; and (2) an internal *filter element*. The device must be attractive, durable, and functional in a low-income setting. The filter element must significantly reduce particles and disease-causing agents in water so that it is safe for families to drink.

Most current HWTS manufacturers produce both devices and filter elements; this can result in purchasers being required to buy proprietary replacement filters for their HWTS device, which reduces competition between manufacturers to lower the price point of filters and forces consumers to buy replacements that may be expensive, may not address their local conditions, or may not be available in their area.

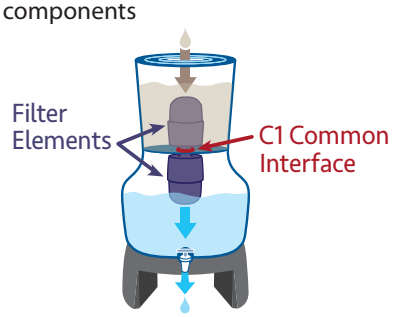
PATH's platform strategy addresses this issue, with the goal of making products more accessible to low-income consumers. PATH designed the new C1 Common Interface, which promotes correct use and enables water filter devices to accept any filter element that is also C1 compatible (see figure below).

The C1 Common Interface allows users to choose the filter element that best meets their needs regardless of brand without replacing their whole device. Filter element makers can more easily partner with water filter makers to reach developing-country consumers. Water filter makers can take advantage of more sourcing and technology options. Proliferation of products with the C1 Common Interface will support higher-volume production, lowering prices for consumers.

The C1 Common Interface makes it possible for companies to specialize in producing devices, producing filter elements, or local assembly and marketing of components produced elsewhere. This opens the market to new companies that might choose to focus on what they do best, rather than having to do it all. For example, if local water conditions call for special functionality, such as a specific type of filter element, an entrepreneur in that country could produce a filter that is guaranteed to fit into a device produced by another manufacturer, perhaps in another country.

The SWP platform strategy also helps steer companies away from the practice of developing proprietary filter elements that fit only one brand of device, forcing consumers to buy replacements that may be expensive, may not address their local conditions, or may not be available in their area.

Figure 2. Water filter device and components



As more companies compete, consumers will see increased choice, increased access, and lower prices. Ultimately, all products made to fit the platform interface will combine to create a significant "installed base" of products that encourage producers to compete to provide replacements.

Additional key advantages of the platform strategy include:

- **C1 Common Interface for interoperability.** This is a design specification that enables a variety of filter elements to be compatible with a variety of HWTS devices, whether the device and filter elements are sold by the same or different brands.
- **"Keep out area"** to ensure compatibility with filter elements produced by various manufacturers. Designers can be creative with the shape and size of the shell, but they must be careful to leave sufficient room inside the upper (untreated water) container for any common interface filter element to fit.
- **Reduced potential to re-contaminate filtered water.** Some HWTS designs make it easy for users to inadvertently re-contaminate treated water stored in the lower container if they remove the filter element while there is still untreated water in the top container. The Reference Design's C1 Common Interface prevents the filter element from being removed if the top and bottom containers are still connected.

Key findings from the user-research incorporated into the Reference Design and Design Guidelines include:

- **Ease of assembly**, with built-in controls to prevent users from installing the filter element incorrectly (orientation control) and other assembly errors.
- **Finger cleanability**. PATH field research showed that most HWTS users would clean the shell and the filter element with their bare hands (not with brushes). For this reason, it was crucial that the Reference Design not contain any crevices, seams, or crannies that could not be cleaned with a finger. In practice, it meant that no features could have a radius of less than 6mm.

PATH's Safe Water Project is currently working with three HWTS product manufacturers in China to produce three different devices based on the Reference Design and with input from the Design Guidelines. In line with the platform strategy, all devices incorporate the C1 Common Interface, so that filter elements from each manufacturer will be interchangeable with devices from any of the manufacturers. Additionally, PATH is working with Cascade Designs, Inc., and other partners to create new filter elements that incorporate the C1 Common Interface. More information about the availability of products based on the platform strategy will be available in early 2012.

Cascade Designs, Inc. | Dukang | Ningbo Clean | PureEasy

PATH is partnering with device and filter element manufacturers to create new devices that will accept a range of filter elements.

Next steps

PATH is broadly disseminating the Reference Design and the Design Guidelines through global safe water networks and newsletters, online, and at international conferences.

PATH anticipates that the new HWTS devices and filter elements that incorporate the C1 Common Interface will be available in early 2012. PATH is seeking field validation partners for these new devices.

As we gain further experience with the new products, PATH plans to update the Design Guidelines, make the specifications of the C1 Common Interface widely available for license, and help additional manufacturers prepare for filter production.

For more information, email newwaterfilters@path.org

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