Peace Corps Improved Cookstoves Handbook

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Acronyms and Abbreviations

CCT Controlled cooking test

CO Carbon monoxide

GIZ German Society for International Cooperation (*Deutsche Gesellschaft für Internationale Zusammenarbeit;* formerly GTZ)

GACC Global Alliance for Clean Cookstoves

ICS Improved cookstoves

IST In-service training

KPT Kitchen performance test

LPG Liquefied petroleum gas

MDG Millennium Development Goals

NGO Nongovernmental organization

PCIA Partnership for Clean Indoor Air

PM Particulate matter

PST Pre-service training

RHC Retained heat cooker

TChar A special kind of TLUD stove that produces charcoal

TLUD Top-Lit UpDraft (gasifier)

USAID United States Agency for International Development

VITA Volunteers in Technical Assistance

VRF Volunteer reporting form

WBT Water boiling test

WHO World Health Organization

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Introduction

Some 3 billion people worldwide, the majority in developing countries, burn solid fuels—wood, crop residues, charcoal, or coal—for cooking and heating, in open fires or rudimentary stoves. This results in the release of dangerous particulate matter (PM), carbon monoxide (CO), and other toxic pollutants and greenhouse gases into the air. The use of solid fuels also puts pressure on local natural resources and carries opportunity costs for the women and children tasked with collecting or buying the fuel.

Four major strategies can reduce dependency on solid fuels for cooking and their impacts:

1. Increase use of alternatives to solid fuels for cooking
2. Increase adoption and proper use of improved cookstoves (fuel-efficient stoves, solar cookers, and retained heat cookers)
3. Improve kitchen and fuel management
4. Other practices to reduce child mortality, including breastfeeding and pneumonia case management

These strategies can have many positive effects for families who traditionally use solid fuels for cooking; they can improve health and reduce the time and burden of collecting firewood, among other benefits.

Following is the Peace Corps' vision statement for its work in improved cookstoves:

> "We are committed to promoting proper use of improved cookstoves that are bought or built by families that use them, as well as other behaviors that reduce infant mortality from pneumonia."

This handbook has been developed for both Peace Corps staff and Volunteers to advise and assist community members with opportunities to reduce their dependence on solid fuels for cooking in ways that are appropriate in their local contexts. This effort focuses primarily on assessment, planning, design, monitoring, and evaluation of an effective improved cookstove program or activity that takes into account recent advances in stove design and recent studies regarding the effectiveness of stove implementation programs in achieving lasting health and environmental benefits.

This introductory section begins with information about the benefits of improved cookstoves, the global movement to promote adoption of improved cookstoves, the role Volunteers can play, and the role posts can play in that effort.

THE ROLE OF VOLUNTEERS

Volunteers can play an important role in communicating the benefits of alternatives to solid fuels and of improved cookstoves, facilitating adoption of improved cookstoves, promoting improved kitchen and fuel management, and promoting other practices that reduce infant mortality as a result of pneumonia.

Four key things to know about improved cookstoves promotion:

- **Users matter!** Stoves must meet the needs of cooks (usually women) or they won't be used.
- **Stove design matters!** Be sure you are using a design that has been reviewed by a stove expert.
- **Fuel management and stove maintenance matter!** These can have as significant an impact on emissions as the stove type.
- **Testing matters!** Testing confirms the benefits of the program and strengthens future improved stove promotion efforts.

Indoor Air Pollution Guidelines

WHO Guidelines for Particulate Matter

$PM_{2.5}$: 10 μg/m^3 annual mean
25 μg/m^3 24-hour mean
PM_{10}: 20 μg/m^3 annual mean
50 μg/m^3 24-hour mean

$PM_{2.5}$ and PM_{10} are particles of pollutants (particulate matter) with diameters of 2.5 micrometers and 10 micrometers or less, respectively. These are small enough to invade and irritate airways in our lungs. The annual/24-hour means are the average concentration of particulates in an environment over a year/24-hour period.

Even small amounts of smoke in the kitchen can cause serious respiratory problems.

Figure 1: Soot from solid fuel cooking on kitchen walls.

Volunteers may also help local microentrepreneurs to begin or strengthen an improved stove business. Volunteers can promote improved cookstoves as a primary or secondary activity. As outlined in the section "Volunteer Cookstove Activity Design and Implementation," the first step Volunteers should take before beginning any improved cookstove activity is to learn more about improved cookstoves and experiences with different types of stoves in their countries of service. This should include a review of current efforts in the community, region, and country to promote improved cookstoves.

THE BENEFITS OF IMPROVED COOKSTOVES

Improved cookstoves address five United Nations Millennium Development Goals:

- Maternal health
- Child health
- Environmental sustainability
- End poverty and hunger
- Gender equality

Health effects

When solid fuels are burned indoors, whether in rudimentary stoves or three-stone fires, as is typical in many Peace Corps communities, the resulting indoor air pollution levels can be 20 to 100 times greater than standards recommended under the World Health Organization's (WHO) air quality guidelines (see box to the left). Cooking outside under a veranda, using a smoke hood, creating the least amount of smoke, using a functional chimney, and increasing ventilation by opening windows and doors are ways to reduce harmful smoke when burning biomass. Studies have shown that infants whose smoke exposures were reduced by 90 percent were 50 percent less likely to suffer from pneumonia.[1]

Women who carry a baby on their back while cooking inadvertently expose the child to high levels of toxic smoke that can negatively affect growth and development. There is consistent evidence that exposure to biomass smoke increases

[1] Smith, Kirk. April 18, 2012, response to *The Washington Post* article "Clean cookstoves draw support, but they may not improve indoor air quality." April 16, 2012.

the risk of acute lower respiratory infections in childhood, particularly pneumonia. Globally, acute lower respiratory infections, in particular pneumonia, continue to be the single leading cause of death in children under 5 years, causing more than 2 million annual deaths in this age group. A WHO comparative risk assessment found that, each year, indoor air pollution is responsible for nearly 900,000 deaths due to pneumonia among children under 5 years of age. Indoor air pollution from household energy is ranked fourth on the list of serious threats to health in less developed countries for all ages, after malnutrition, unsafe sex, and unsafe water.[2,3,4,5]

In addition to acute respiratory infections, other health outcomes associated with exposure to indoor air pollution include chronic obstructive pulmonary disease, such as chronic bronchitis; lung cancer (for users of open coal stoves); cataracts; tuberculosis; nasopharyngeal and laryngeal cancers; cardiovascular disease; asthma attacks; adverse pregnancy outcomes (stillbirth, low birthweight); and early infant death.[6]

Additional health impacts from collecting and burning solid fuels include burns and scalds; eye irritation and infections; headaches; backaches from tending fires on the floor; and injuries and assaults incurred during fuel collection, which can include back and neck injuries from carrying heavy loads of fuel, snake and insect bites, and attacks, including rape. Because household cooking tends to be considered the domain of women, and by association their children, women and children disproportionately suffer from these impacts.

Of note, while women may associate indoor smoke with coughing and eye irritation during the cooking period, many are unaware of the longer term health impacts. In communities in which the vast majority of cooks are exposed to high levels of indoor air pollution over a lifetime, women may see cataracts as just something everyone eventually suffers, and pneumonia as a common and perhaps unpreventable childhood illness.

Properly designed, used, and maintained, improved cookstoves with chimneys can reduce indoor air pollution levels [for both carbon monoxide (CO) and particulate matter ($PM_{2.5}$)] by 90 percent or more.

Environmental effects

The inefficient burning of wood and charcoal for cooking and heating increases pressures on local natural resources, and can exacerbate deforestation. Fuel-saving stoves can slow the degradation and help ease tensions over the use of, and access to, these natural resources.

Traditional cooking and heating methods release greenhouse gases, primarily carbon dioxide and methane, and are also a major source of black carbon, an important short-lived climate forcer.[7]

Properly designed, maintained, and used improved cookstoves can reduce fuelwood use by 50 percent or more and can reduce emissions of greenhouse gases, including carbon dioxide, as well as black carbon, which also contributes to global warming.

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[2] World Health Organization, World Health Report 2002; http://www.who.int/indoorair/health_impacts/en/

[3] WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide Global update. 2005

[4] Bruce N., Neufeld L., Boy E., West C. *Indoor biofuel air pollution and respiratory health: the role of confounding factors among women in highland Guatemala*. Int J Epidemiol, 27: 454-48. 1998.

[5] Ezzati, Majid; Kammen, Daniel M. "Indoor air pollution from biomass combustion and acute respiratory infections in Kenya: an exposure-response study." *THE LANCET* • Vol 358 • August 25, 2001.

[6] Smith, K.R. "Indoor air pollution in developing countries: recommendations for research." *Indoor Air.* 12: 198-207. 2002.

[7] A "short-lived climate forcer" is a pollutant that contributes to climate change but over much smaller time scales than carbon dioxide.

Social, economic, gender, and user-perceived benefits
Time and money spent on gathering and buying fuel limit options for school attendance for children and more productive income-generating opportunities for women, perpetuating cycles of poverty. Women who cook with solid fuels may also lose time spent sick or injured, or caring for sick or injured children, as a result of health effects of traditional cooking activities. Fuel collectors are also at risk of assault and harassment that can occur while collecting fuel.

Women using improved cookstoves have reported benefits of less time and effort required to clean pots and kitchen walls, due to reduced soot, and less time required to prepare meals. Additionally, less time is required for the collection of biomass fuels (i.e., wood, animal dung, crop waste).

The production and sale of improved cookstoves can provide important income-generating opportunities for local manufacturers and sellers.

Schools in countries where many Volunteers serve participate in school breakfast and lunch programs. In rural areas, schools often do not have sufficient funds to hire an employee to cook, so parents take turns preparing meals for the students. In some cases, children are required to bring fuelwood to school in order to attend. Installing an improved cookstove, such as a solar oven or biomass institutional stove, will help the school save money on fuel, which can be used to purchase healthier ingredients for meals or to extend the meal program to more students.

THE GLOBAL ALLIANCE FOR CLEAN COOKSTOVES (GACC)

Building on eight years of work by the Partnership for Clean Indoor Air, the Global Alliance for Clean Cookstoves was launched in 2010 as a new public–private partnership to save lives, empower women, improve livelihoods, and combat climate change by creating a thriving global market for clean and efficient household cooking solutions. The Alliance's "100 by 20" goal calls for 100 million homes to adopt clean and efficient stoves and fuels by 2020, an effort which Peace Corps Volunteers can help support. GACC works with public, private, and nonprofit partners, aiming to help overcome the market barriers that currently impede the production, deployment, and use of clean cookstoves in the developing world.

PEACE CORPS CRITERIA FOR IMPROVED COOKSTOVES

In 2011, the Peace Corps adopted the following criteria with the goal that the cookstoves promoted by the agency and by the Volunteers are consistently and sustainably used, are properly maintained by community members, and achieve the desired health, environmental, and socioeconomic impacts.

Improved cookstove options that Volunteers or other development workers promote must be

- **Desirable:** appropriate for cooks' needs and preferences, compatible within the cultural context.
- **Accessible:** available and enabling choice, affordable outright or otherwise—e.g., micro-credit, self-help groups, etc.
- **Effective:** actually reduce levels of indoor air pollution and fuel use. Specifically related to this criterion, the Peace Corps aims to promote stoves that (a) consume at least 35 percent less fuel when cooking a typical meal than the traditional stove currently in use; (b) achieve a reduction in air contamination by use of a chimney for indoor stoves; and (c) where data is available or can be obtained, achieve at least a 90 percent reduction in emissions or exposure, as confirmed by either a standard controlled cooking test or a kitchen performance test conducted in the country.
- **Reliable:** consistently performs as expected.
- **Maintainable:** easy to use and clean; spare parts and service available.

When selecting stoves for promotion in a community or in the country, staff and Volunteers should determine desirability based on cooks' needs and preferences through the baseline survey that can be found in the Improved Cookstoves training package, "Initial Cookstoves Assessment" session. They should also allow community members to try using different models of demonstration stoves. They can then assess whether the cooks' needs have been met using user surveys adapted from the model included in the Improved Cookstoves training package's "Improved Cookstoves Activity Planning and Monitoring" session. Staff and Volunteers may determine accessibility, reliability, and availability of spare parts by interviewing stove suppliers and users, as well as by implementing pilot projects. Effectiveness is best determined by reviewing published results of tests done by qualified, independent stove testers. However, effectiveness data is not available for many stoves. For stoves with no available data, Peace Corps staff and Volunteers can a) partner with or contract a qualified independent stove testing group to verify how well a stove performs, and/or b) train staff and Volunteers to conduct field tests.

THE ROLE OF PEACE CORPS POSTS

If your post or project is considering a new initiative to promote improved cookstoves, or if your post would like to improve the effectiveness of its cookstove promotion efforts, whether as part of project goals and objectives or as a common secondary project supported by post, consider the following recommendations for maximum impact:

- **Designate one staff person to play a lead role** in the cookstove program. This person should become familiar with all materials in this handbook, the Peace Corps Improved Cookstoves Training Package, and the shared annexes for these two resources, distributed with the Improved Cookstoves Training Package. Additionally, the person should network with other organizations in the country that are promoting improved cookstoves and get input from experts in improved cookstoves on recommended approaches and technologies. This person should also be the lead person to monitor and evaluate your cookstove efforts, including ensuring that the Peace Corps Cookstoves Baseline Survey (included with the Peace Corps Improved Cookstoves Training Package on the Intranet) is translated into the local language.
- **Contract or form alliances with at least one expert** in improved cookstoves to provide input and feedback on project design. For information on organizations in your country working on improved cookstoves, see the partners section of the Global Alliance for Clean Cookstoves website, http://cleancookstoves.org/the-alliance/partners/.
- Be sure that your Volunteer Reporting Forms (VRF), either under a primary or a secondary activity objective, include the recommended **outcome indicators** for cookstoves.
- **Prioritize your cookstoves work in regions of the country where families cook indoors.**
- **Prioritize your cookstoves work in regions of the country where families use and pay for firewood or walk long distances to obtain firewood** or other solid fuel.
- **In consultation with stove experts, *select several models of stoves to promote.*** Promote only stove designs that meet the Peace Corps' criteria for improved cookstoves and that are suited to local needs and conditions. In other words, if you are promoting stoves manufactured or promoted by others, request stove performance data. If you are promoting stoves developed, adapted, or enhanced by staff, partners, or Volunteers, test your stove models or pay an independent party to test them. Also choose stove models that are affordable to stove users.
- **Determine the extent to which you will likely promote the concept of *integrated cooking,*** including retained heat cookers and solar cookers.
- **Train Volunteers.** See the section "Training Volunteers" for recommendations.

HOW TO USE THIS TRAINING HANDBOOK AND ACCOMPANYING TRAINING PACKAGE

This handbook and its companion Peace Corps Improved Cookstoves Training Package have been developed for use by Peace Corps posts worldwide, recognizing both that circumstances vary widely from post to post and site to site, and that the fields of stove design and testing methodologies are dynamic. Therefore, information about specific stove options, stove design manuals, stove testing protocols, and research study results are included as references and annexes that can be easily updated. The most widely applicable references, for example, stove testing protocols, are included electronically with the training package on the Peace Corps Intranet site. For other external references, website locations are included at the end of the handbook so the latest document can be downloaded. For other Peace Corps references, as well as links to additional references, you may also consult the Peace Corps "Knowledge 4 Health" (K4 health) website at http://www.k4health.org/toolkits/improvedstoves, or contact the Peace Corps Office of Overseas Programming and Training Support (OPATS). You may also contact other posts for their specific resources.

Peace Corps staff and Volunteers are encouraged to modify the assessment forms as needed and to promote stoves that are appropriate to the populations they serve. However, please be aware that adaptations of stove designs without understanding stove design principles and without testing the modifications may result in Peace Corps' promotion of stoves that do not reduce fuel use very much, or at all, and do not reduce emissions and may actually increase them.

The text of the handbook includes a basic introduction to cooking alternatives to solid fuels, kitchen and fuel management, and improved cookstove options, followed by guidelines for Volunteers on cookstove activity assessment, design and implementation, and monitoring and evaluation. There is a short section on training Volunteers and references.

Alternatives to Solid Fuels

Figure 2: Liquefied Petroleum Gas (LPG) Stove. *Photo courtesy of Aprovecho Research Center*

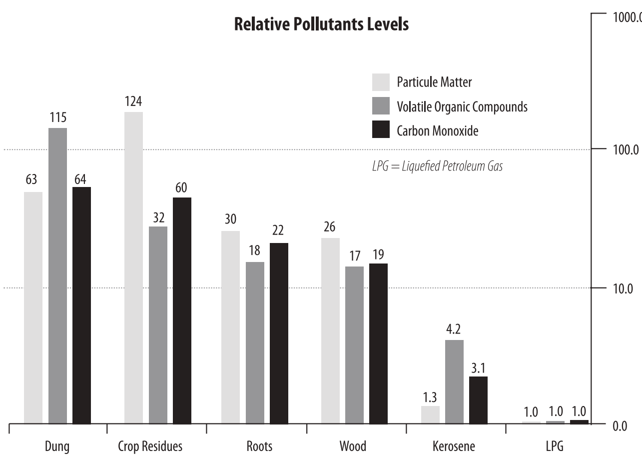

Figure 3: Comparison of Emissions by Fuel Type
Graph courtesy of the Partnership for Clean Indoor Air (PCIA Bulletin No. 26: LPG)

Even when burned in the cleanest stoves currently widely available, solid fuels used for indoor stoves without properly functioning chimneys can result in CO and PM emissions that far exceed World Health Organization (WHO) exposure guidelines. The alternatives to solid fuels presented here can eliminate or greatly reduce indoor air pollution when used either exclusively in place of solid fuels, or as a complementary cooking option when several different cooking methods are regularly used—in what is referred to as "integrated cooking."

ELECTRICITY, NATURAL GAS, AND LIQUEFIED PETROLEUM GAS (LPG)

Electricity and gas (natural gas or liquefied petroleum gas [LPG], the latter sold in pressurized metal canisters as indicated in the photo to the left) are far less polluting than solid fuels. This is illustrated in Figure 3, comparing the typical emissions of three pollutants from the burning of six types of fuels to generate the same amount of energy: LPG is the cleanest burning fuel by far, while dung and crop residues contaminate air the most. Note that the chart does not show the wide variations in emissions that exist for wood-burning stoves.

Volunteers may want to help community members find a way to purchase the equipment necessary to take advantage of these options in places with a regular supply and distribution system for electricity or gas. Volunteers should work with community members to understand not only the initial investment cost, but also the ongoing costs for gas or electricity that such options entail. Options for addressing cost barriers may include facilitating access to micro-credit for stove and cylinder purchase, including through micro-savings programs, and focusing on smaller cylinders with lower upfront costs. Electricity and gas can be used exclusively, or in parallel with improved cookstoves if exclusive use is prohibitively expensive.

SOLAR ENERGY[8]

Solar energy is widely available and beneficial. An optimum concentration and number of hours of direct sunlight occurs within 30 degrees north and south of the Equator, therefore, the high solar insolation rates in these regions can provide free, zero emission energy to cook food and boil water for six to eight hours a day up to nine months a year using one of the three types of solar cookers described on the following pages.

[8]This sub-section largely provided by Solar Cookers International.

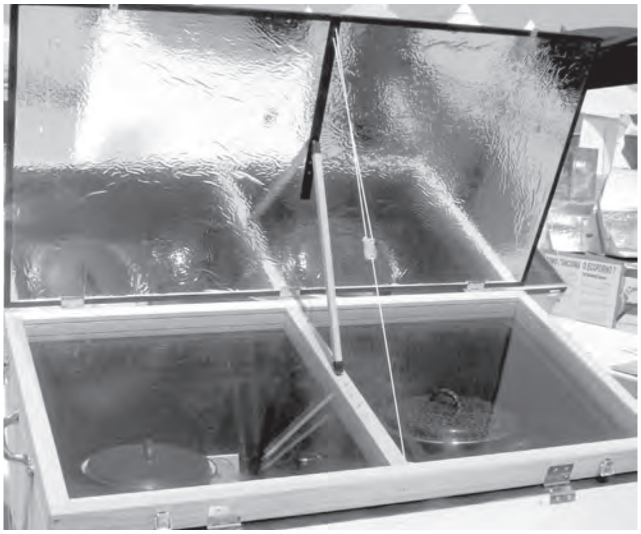

Figure 4: Box solar cooker. *Photo courtesy of Solar Cookers International* http://solarcookers.org/basics/how.html

Figure 5: Panel solar cooker. *Photo courtesy of Solar Cookers International*

Figure 6: Parabolic Solar Cooker. *Photo courtesy of Solar Cookers International*

Because solar cookers do not cook during the early morning or at night, they should be promoted as part of an integrated cooking system—alongside improved stoves and, ideally, retained heat cookers (RHCs). RHCs, described in more detail in the next section, allow meals cooked in the afternoon to be served still hot after dark.

There are three principal types of solar cookers: 1) **a box cooker:** a glass-topped container that converts sunlight into heat and cooks like an oven at up to 350F (176C), 2) **a panel solar cooker:** smaller and less expensive than a box cooker, can be folded flat for storage, and also cooks like an oven but at 250F (121C), and 3) **a concentrating parabolic reflector.**

Box and panel solar cookers are best suited for foods that are cooked slowly and evenly, including breads and cakes. They can also be used to pasteurize milk and drinking water and to heat water for non-cooking purposes, such as bathing and cleaning.

Since box and panel solar cookers never reach combustion temperatures and pose no fire hazard, they can be safely left to cook unattended in the sun. They can be made with locally available cardboard, wood, metal, glass, and reflective materials. More durable, manufactured models are available from Europe, the United States, India, South Africa, Mexico, and China.

The concentrating parabolic reflector cooker focuses an intense beam of sunlight on the bottom of a cooking pot and immediately reaches combustion temperatures above 451F (232C). This design can cook food and boil water as fast as an open fire or gas burner. On a clear day, a parabolic reflector can cook from sunrise until sunset, even in below freezing temperatures. Parabolic solar cookers are available in small and medium sizes for family use. Most are manufactured, but some cement models are made locally by hand. Large institutional parabolic solar cookers allow cooks working inside a kitchen or in the shade to prepare meals for hundreds of people using only the light of the sun, with gas or wood backup stoves available for use on cloudy days. Parabolic cookers should never be left unattended, since they generate enough heat to start a fire and because unless automated, they need to be adjusted every 10 to 15 minutes to ensure that the reflective parabola is continuously tracking the sun.

The type of solar cooker introduced will depend on local cooking preferences: e.g., parabolic solar cookers for tortillas and fried or boiled food; box or panel cookers for baked, roasted, simmered, and stewed foods. Solar cookers will require substantial training and follow-up, although they are understandably more rapidly accepted in regions where biomass is difficult to obtain. Solar cookers require a lightweight black pot for maximum solar thermal absorption. Inexpensive steel or aluminum pots purchased in local markets can be painted black on the outside with nontoxic blackboard paint or blackened with soot.

The table on the following page provides some comparative information on the three solar cookers.

For more detailed information about using solar cookers in developing countries, see the references included in the solar cookers annex.

BIOGAS

Biogas, produced in biodigesters from food and other organic waste, is being used successfully for cooking in many rural communities. Peace Corps Volunteers have been successfully promoting the use of biogas in Thailand and in Nicaragua. Details from biodigester manuals from each of these Peace Corps countries are included in the reference section for this handbook. However, experience in many developing countries has been that biodigester use of household cooking is often not sustained over time.

Figure 7: Biogas generation. *Photo courtesy of Aprovecho Research Center*

Biogas is a methane-rich gas produced when biodegradable organic material, including agricultural residue or dung (can include human feces), is broken down by bacteria in the absence of oxygen, known as anaerobic digestion. It burns cleanly and easily in conventional low-pressure type gas burners, and can even be used for lighting with special lamps.

Biogas is formed in biodigesters. In addition to producing biogas, biodigesters produce an effluent that can be used as fertilizer. Biodigesters come in many forms, from inexpensive plastic bag models to floating and fixed-dome models. Household-level digesters are available and are a best fit for families that have several cows or pigs, as quantities of human excreta alone are not typically adequate. Some specialized household biodigesters do exist that rely entirely on (agricultural) waste starches.

Biodigesters are most appropriate for communities with significant agriculture and animal husbandry. In locations where sanitation services are lacking, biogas systems connected to latrines can provide an important additional service. Cooking with biogas has been more widely accepted in Asia than in Africa or Latin America, although successful programs exist in all three regions. The plastic bag model biodigester

Solar cooker Type:	Materials/Production	Cost Range	Pros	Cons	Suitable for
Panel	Prefabricated: polished aluminum, foldable reflector panels Locally assembled types: Cardboard, glue, aluminum foil, welded sheet metal, mylar-coated, waterproof plastic reflector	$10–$100	■ Can last 5–10 years if reflector is made of durable waterproof materials ■ Portable/easy to store and clean ■ No fire hazard ■ Zero emissions, zero fuel consumption ■ Cooks at 250F (121C) ■ Requires no stirring of food ■ Will not burn food ■ Needs to be rotated only once every one or two hours ■ Safe for children to use	■ Does not work well in very cold temperatures ■ Cooks more slowly than an open fire ■ Requires sun at 45-degree angle or higher to reach optimal cooking temperature ■ Should be staked down if used in windy conditions ■ Locally assembled types, unless waterproofed, will deteriorate if food or water is spilled on reflector	■ Transient or settled populations in sunny regions ■ Cooking beans, lentils, corn meal, rice, vegetables, stewing fruits, roasting meat, fish, heating water for tea or coffee, baking bread and cakes, baking potatoes
Box	Prefabricated: Container: Molded plastic or metal Aluminum reflectors Locally assembled: Container: sheet metal, wood, cardboard, cob (mud and chopped straw)	$30–$250	■ If insulated, can cook in freezing temperatures ■ Can hold several cooking pots ■ No fire hazard ■ Zero emissions, zero fuel consumption ■ Cooks at up to 350F (176C) ■ Requires no stirring ■ Will not burn food ■ Needs to be rotated only once every one or two hours ■ Safe for children to use ■ Can also serve as retained heat cooker	■ Cooks food more slowly than an open fire	■ Settled populations in sunny regions ■ Cooking beans, lentils, corn meal, rice, vegetables, stewing fruits, roasting meat, fish, heating water for tea or coffee, baking bread and cakes, baking potatoes, drying produce, roasting nuts
Parabolic Factory-made	Models sold online and in China, Germany, India, South Africa, and Spain and are made of polished aluminum, fiberglass, cast iron, or reinforced concrete mounted on steel tube frames	$30–$800	■ Zero emissions, zero fuel consumption ■ Cooks as fast and as hot as an open fire or stovetop burner ■ Cooks food and boils water from sunup to sundown as long as there is direct sunlight ■ Large concentrators can boil, fry, or stew institutional sized pots of food for schools, health centers, community kitchens	■ Concentrated sunlight requires the same safety precautions as open fire ■ Users must protect their eyes from the glare of the reflected light by standing in the proper position relative to the sun while cooking ■ Requires adjustment every 10–15 minutes to track the sun ■ Should be staked down when used in windy conditions	■ Frying, boiling, making flat bread/tortillas, hot water for tea, heating irons for pressing clothing (replaces charcoal fires used for non-electric irons) ■ Can be used for preparing any food that can be cooked over an open fire

promoted by many Peace Corps Volunteers has a limited life, from three to six years, depending on the quality of the plastic and environmental factors, so Volunteers should take this cost into account when planning for sustained use of biodigesters.

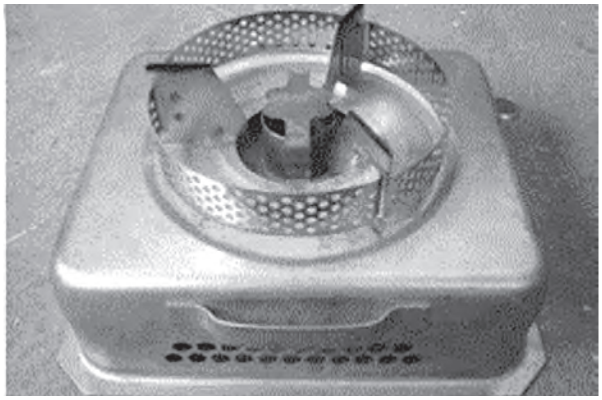

Figure 8: Alcohol stove. *Photo courtesy of Aprovecho Research Center*

ALCOHOL

Alcohol fuels (ethanol and methanol), when burned in properly designed stoves, burn very cleanly, with safe air quality levels based on WHO air quality guidelines. An alcohol stove provides both high and low power and is very convenient compared with cooking with biomass. They are extinguishable by water, and their vapors are not prone to explosion in air (as can happen with LPG). Because alcohol produces a clear blue flame that is difficult to see, it must be burned in a stove that encloses the flame to avoid accidental burns, especially among children, who may not realize the stove is on. In addition to cost, securing a steady source of alcohol fuel supply can be a challenge to adoption and sustained use of this cooking system. Alcohol catches fire easily and the flame can spread if the fuel is spilled accidentally. Methanol, a type of alcohol, is a toxic substance, so its use needs to be considered in terms of safety concerns.

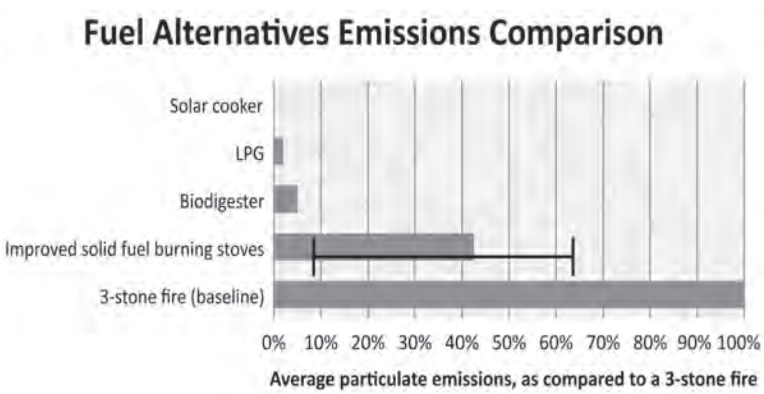

Figure 9: Comparison of emissions for stove types based on fuel source. *LPG = Liquefied Petroleum Gas;TLUD = Top-Lit UpDraft gasifier type wood-burning cookstove. Data sources for this figure are:[9,10,11,12] Note: black lines represent range of emissions results covering a range of stove types.*

EMISSIONS COMPARISON

As Figure 9 indicates, the alternatives to solid fuels (e.g., solar cookers, LPG, and biodigesters) produce emissions 90 to 100 percent less than a three-stone fire. Improved solid fuel burning stoves also produce emissions ranging from 35 percent to 80 percent less than a three-stone fire. In other words, these alternatives to solid fuels tend to be significantly less contaminating than solid fuel burning stoves. Electrical stoves are also very clean in the kitchen environment, but are not presented in the figure below because net emissions for electrical stoves would also need to consider the energy profile of the country.

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[9] "Liquefied Petroleum Gas: An alternative cooking energy in Uganda," presentation at February 2011 PCIA Forum, Dr. Emmy Wasirwa, managing director, Wana Energy Solutions

[10] Kandpal, J.B., Maheshwari; R.C., Kandpal; Tara Chandra. "Biogas: Indoor air pollution from combustion of wood and dung cake and their processed fuels in domestic cookstoves." Centre for Rural Development and Technology and Centre for Energy Studies, Indian Institute of Technology, Delhi, Hauz Khas, New Delhi 110 016, India (Received 10 December 1993; received for publication 16 December 1994)

[11] "Micro-gasification: Cooking with gas from biomass." January 2011, GTZ *http://www.gtz.de/de/dokumente/giz2011-en-micro-gasification.pdf*

[12] Jetter, James; Kariherb, Peter. "Solid Fuel Household Cook Stoves: Characterization of Performance and Emissions." 2009

Kitchen and Fuel Management[13]

In addition to using improved cookstoves, cooks can reduce fuel use and indoor air pollution significantly by employing some simple kitchen and fuel management tactics described in this section: improved kitchen ventilation, meal planning, stove/fire management, pot management, and use of retained heat cookers. Helping families make simple changes to improve kitchen and fuel management, as well as other practices that reduce child pneumonia discussed in the next section, should be a regular part of any improved cookstoves activity.

Figure 10: Example of good ventilation with gap between kitchen wall and roof, Bangladesh. *Photo courtesy of Aprovecho Research Center*

IMPROVED KITCHEN VENTILATION

Cooking outdoors, when feasible and acceptable, is normally the best option to reduce exposure to smoke. Where cooking is done indoors, improved kitchen ventilation can be achieved through the use of chimneys, smoke hoods, windows, and ventilation holes. Smoke hoods are placed over a traditional fire or a stove, helping draw hot air and smoke out of the room. Ventilation holes may be made in roof eaves or in the peak of the ceiling or roof, but likely will need to be covered so rain doesn't come in. Ideally they should be closable when not needed. Ventilation is greatly affected by wind and by temperature differences. In general, a large temperature difference between indoors and outdoors promotes ventilation. For more information, go to www.aprovecho.org for studies in ventilation and its effect on indoor air pollution.

MEAL PLANNING

Pre-soaking hard foods such as beans and some grains (faro, rye berries, millet) in water for several hours before cooking reduces the cooking time needed, as does the use of tenderizing methods, such as filtering water through ash to cook beans.

STOVE/FIRE MANAGEMENT

For most types of traditional and improved cookstoves, cooks should not overstuff the stove with fuel. This makes combustion less efficient by restricting air flow, which results in increased fuel consumption. It can also cause excess smoke production and may even damage the stove.

Stoves should also be placed in a position where they are protected from strong winds that may cause the fire to burn too quickly or to produce excess smoke.

Lifting the stove from the floor to waist height will reduce the need for bending over the fire when tending it, which reduces exposure to smoke for the cook. This may reduce exposure to smoke for children playing on the floor or ground, as well.

[13] This section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Tool B: Fuel-Saving Cooking Methods, Pages 150-151 and Step 5, Pages 89-90.

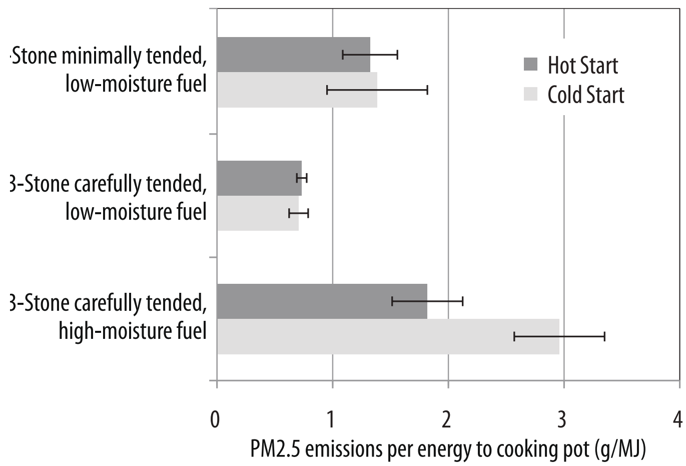

Figure 11: Comparison of fuel emissions relative to fuel management (how well tended and moisture level). *Slide courtesy of James Jetter, US-EPA, from "What's Hot in Cook Stove Testing, Fuels, and Technology," PCIA Forum 2011. Note: black lines represent margin of error in the test results.*

Chimneys and combustion chambers need to be cleaned regularly, and cracks in chimneys need to be fixed or the chimney should be replaced to ensure adequate air flow and to minimize smoke in the kitchen.

FUEL MANAGEMENT

Fuel management can have a significant impact on fuel efficiency. Studies have shown that $PM_{2.5}$ emissions can be three to four times higher for high-moisture fuel as compared with dry fuel (see Figure 11). Fuelwood should be dried well and cut to the appropriate size.

Burning wet or freshly cut ("green") wood diverts heat toward the evaporation of water, and produces much higher emission levels due to incomplete combustion. Burning dry wood produces a more even burn, lower emissions, and less creosote. Carefully controlling the amount of fuel burned by reducing fuel size and by burning only the tips of sticks will result in more complete combustion. The size of fuel will depend on the fuel, stove, and cooking task. See Design Principles of Wood Burning Cookstoves in the reference section for further guidance on maximizing fuel efficiency.

Finally, when cooking is complete, the fire should be extinguished rather than being allowed to burn out on its own. A smoldering fire tends to produce smoke and more toxic emissions. Extinguishing the fire can be done by stirring the wood and ash to extinguish all flames, and then sprinkling water over the coals, or mixing the embers with dirt.

POT MANAGEMENT

Using pot lids is another way cooks may be able to reduce fuel use, by reducing boiling time and the power needs of the stove. Use of lids will only translate into greatly reduced fuel usage if the cook has a way to turn down the heat once the pot reaches the simmer stage, which can be difficult with open fires and many cookstoves. Using a pot made of the best material for the food being cooked can also help reduce fuel needs; metal pots heat quickly but retain little heat, and thus are good for boiling or quickly frying food; clay pots retain heat and are good for slowly cooking such foods as beans or stews. Cooks can also save cooking time and fuel needs by warming a second pot of food by placing it on top of the main pot or using a multi-pot stove.

RETAINED HEAT COOKER/HAYBASKET/HAYBOX

A retained heat cooker (RHC), also known as a haybasket or haybox, is an insulated container in which boiling pots can be placed to keep cooking without further use of the stove or fuel, thereby reducing fuel requirements and the time that the stove is burning. RHCs are made out of an outer container (which can be a basket, cardboard box, plastic container, or other material) lined with insulating materials such as cloth, grass, straw, or agricultural waste, and a tightly fitted lid. As a rule of thumb, lightweight materials are good insulating materials as they contain trapped air that slows the transfer of heat. The RHC should be built to snugly fit the pot with which it will be used. RHCs are best suited for cooking legumes and grains, which cook slowly with low heat. Retained heat cookers are also appropriate for use with solar cookers, helping keep food hot until mealtime. For an RHC to work properly it is important the insulating material is kept dry.

Figure 12: Retained heat cookers. *Photo courtesy of Patricia McArdle, Solar Cookers International*

Once the pot of food is brought to a boil on a stove and allowed to simmer for a few minutes, it is then taken off of the stove and placed into the RHC and covered. The amount of time that food must remain in the sealed RHC will vary by the type of food. A general rule of thumb is that the RHC will require one and one-half to two times the normal stovetop cooking time. The RHC need not be tended during this time, so cooks are free to use their time elsewhere. In fact, the RHC should not be opened while food is cooking, or heat will be lost. RHCs are portable and are comparatively simple to make and use, although training, patience, and practice are vital to successful use of this technology. Many potential users may be initially skeptical about its utility. Production of the cooker can be incorporated into a livelihoods activity for women or men.

For more information, see the USEPA-published *Guide to Designing Retained Heat Cookers,* available in English and Spanish (see annexes).

Other Practices That Reduce Child Pneumonia Mortality

Experts in the health field agree that increased adoption of improved cookstoves will decrease child mortality rates due to pneumonia or other respiratory ailments. However, Peace Corps Volunteers should understand, and work with families as appropriate, to adopt the following additional practices to reduce child pneumonia.

1. ***Reduce child exposure to smoke.*** Keep infants and children out of the kitchen, away from smoke during cooking periods, if there is a safe supervised alternative.
2. ***Breastfeed.*** The health community promotes exclusive breastfeeding for infants 0–6 months, and continued breastfeeding (with supplements) from 6–23 months. Research studies have shown that babies breastfed for less than six months, compared with those who were breastfed for six months, were more than four times as likely to develop pneumonia during their first two years.[14]
3. ***Zinc supplement.*** While perhaps not always available for communities where Volunteers serve, zinc taken in vitamin form as a supplement has been shown to reduce pneumonia by 13–41 percent.[15]
4. ***Immunize.*** Immunized children have a lower risk of catching pneumonia. Immunization against Haemophilus influenzae type b (Hib), pneumococcus, measles, and whooping cough (pertussis) is the most effective way to prevent pneumonia.[16]
5. ***Management of pneumonia cases.*** When children have pneumonia, their chances of survival are greater when they receive care from a person trained to manage pneumonia cases, either within the community or at a health facility.

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[14] http://www.medpagetoday.com/OBGYN/Pregnancy/2634
[15] http://minochahealth.typepad.com/gut/2011/02/zinc-pneumonia-supplements.html
[16] http://www.who.int/mediacentre/factsheets/fs331/en/index.html

Improved Solid Fuel Cookstoves

There are many types of stoves for burning solid fuels that reduce fuel consumption and air pollution significantly compared with a three-stone fire or traditional stove. Some are portable and can be used both indoors and out. Others are fixed within the home. Some have chimneys and some do not. Some rely on gasification, and some produce charcoal as a byproduct. This section details some of the types of stoves promoted by development workers in rural settings, and strategies for selecting the most appropriate options to promote.

Regardless of the option(s) chosen, good maintenance of stoves and chimneys, where present, is key to increasing their longevity and achieving anticipated indoor air pollution reductions. The two slides that follow show the importance of stove maintenance. Figure 13 represents the impact on wood consumption that an improved cookstove (Inkawasi) in Peru was shown to have, by level of maintenance and training. Two data points show how results vary between users in Santiago and in the community of Sanagoran. The results show that stove maintenance is at least as important as stove type for achieving reduced fuel consumption results.

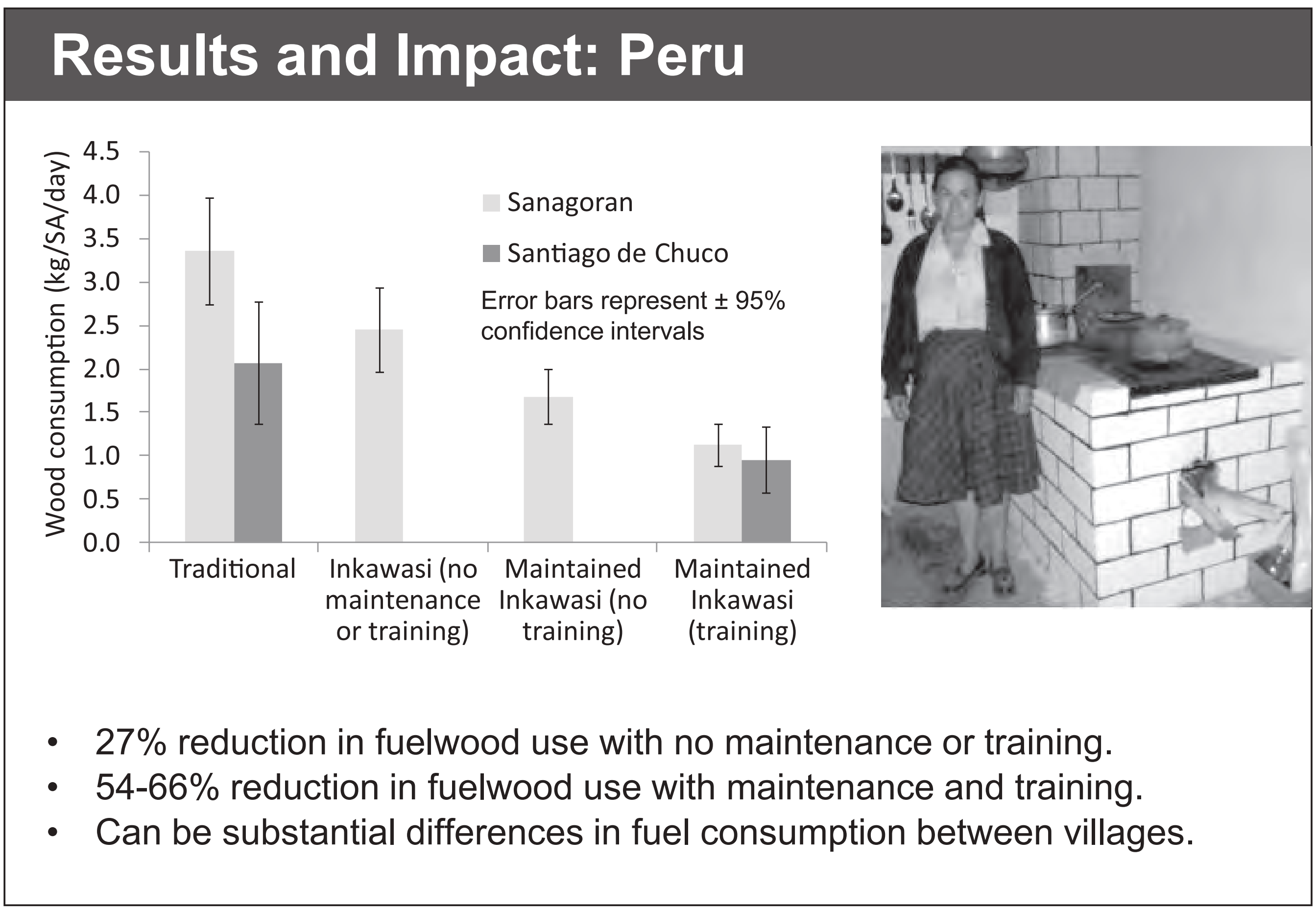

Figure 13: Comparison of emissions for traditional and improved (Inkawasi) stoves, with and without maintenance.
Slide courtesy of the Partnership for Clean Indoor Air, US-EPA

Figure 14 shows the results of a significant epidemiological study in Guatemala, again highlighting a range of both emissions and health impacts of both improved and traditional stoves, depending on stove maintenance and operation variables. This figure shows that a poorly operated and maintained improved cookstove may emit more air pollution than a well-tended open fire, with no corresponding impact on reducing pneumonia cases.

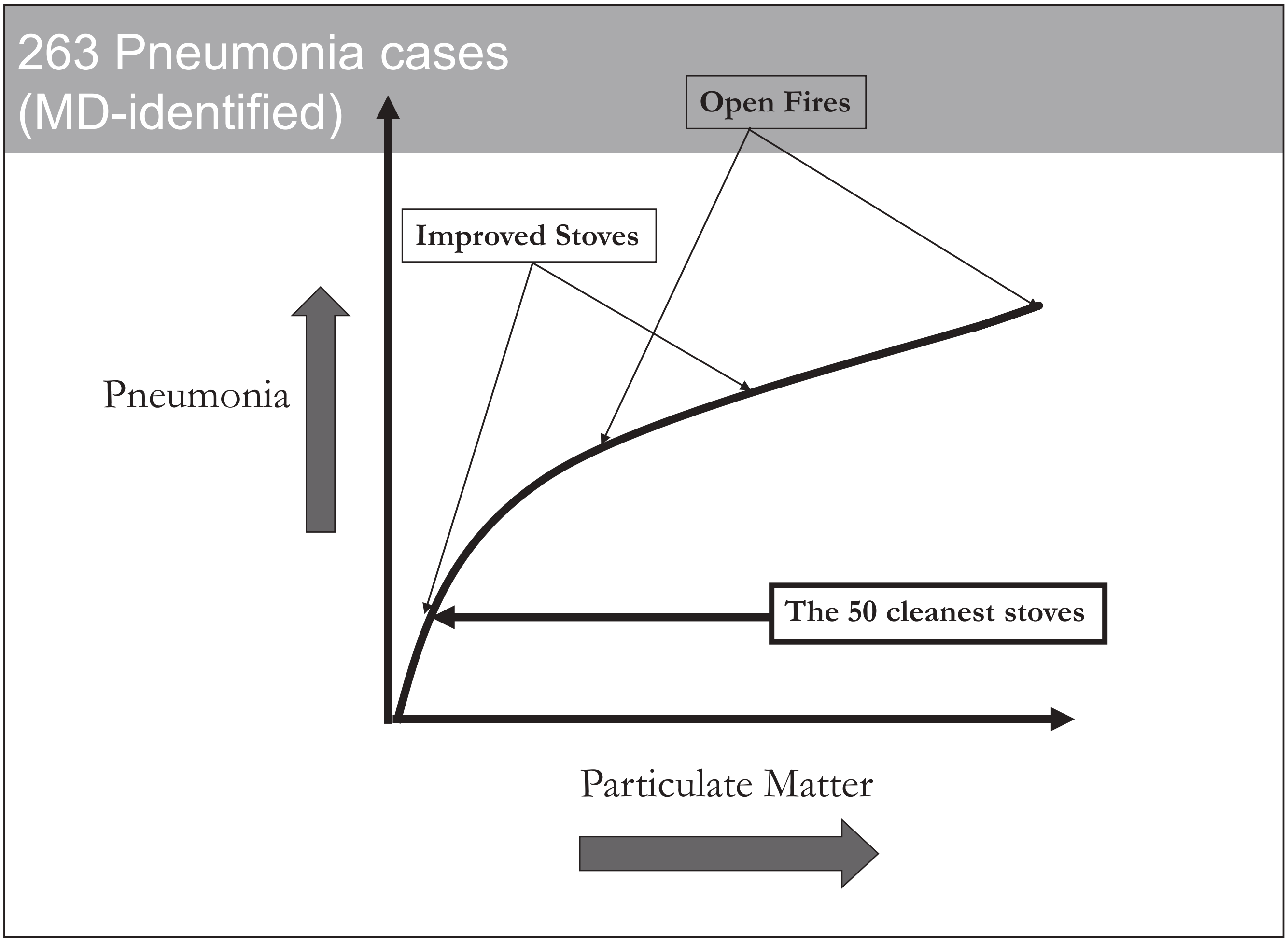

Figure 14: Pneumonia cases related to particulate matter emissions of improved stoves and open fires, from the Respire study, Guatemala. *Slide courtesy of Kirk Smith, from RESPIRE-GUATEMALA, Randomized Exposure Study of Pollution Indoors and Respiratory Effects, PCIA Forum, Lima, February 2011, Lisa Thompson, University of California, Berkeley, University of California, San Francisco*

FACTORS THAT INFLUENCE APPROPRIATE STOVE SELECTION[17]

Posts and Volunteers are encouraged to promote a range of stove options, all appropriate to the local environment, culture, and society, but with a range of costs, and often including both indoor and outdoor options. Remember that the ideal stove program has no subsidy or a low subsidy, so users must be willing to pay for the options selected.

Improved stoves can be categorized in a variety of ways, based upon design principles, construction materials, fuel type, and other factors. This section focuses on stoves that burn wood for cooking (as opposed to heating) and are likely to be promoted by Volunteers, and divides them into types based on their design, which are then subdivided based on construction material.

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[17] This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 69-71.

Primary considerations that influence stove selection are

- **Cooking habits and user acceptability.** At what times of day do people cook? Do they cook indoors or outside? What are the types of food and methods of cooking that are used locally (e.g., frying, baking, simmering, vigorous stirring, etc.)? What are user preferences and concerns related to typical number and types of pots cooking at a time, time needed to cook, and regular use of a griddle of what size, etc.? Community members need to be sufficiently content with the design so they will not modify the dimensions of the stove once it is in their home; *even a small change in stove characteristics can have a significant impact on fuel consumption and emissions.*
- **Fuel type.** What type of fuel(s) will the stove be designed to burn (wood, charcoal, dung, etc.)? What fuel options are available?
- **Local materials.** Are local materials (mud, clay, agricultural or plant waste) suitable for stove-building readily available? Are sheet metal goods produced locally and available in the marketplace? Are chimney materials and replacement chimneys available?
- **Costs and financial resources.** What is the cost of the various stove options? What are users able to pay initially and over time? What financial resources are available to offset the stove costs?
- **Durability.** Some low-cost stoves last only three months, while others can work well for 10 years. Unfired mud or clay stoves may erode more easily in long rainy seasons and high humidity. It is important for Volunteers, partners, and community members to have information about stove durability.
- **Stove use for home heating.** In most cases, stoves are used for cooking and are not intended to heat homes. Excess heat generated by a stove is considered a waste of energy. However, in cold climates, stoves may intentionally be used to heat homes.

Volunteers should always promote stoves and approaches that are fully sustainable locally. Depending on the local economy and stove preferences, these approaches might include:

- Training local masons to build stoves; they could then be paid either in cash or in kind to build stoves for other members of their community or nearby communities. In Guatemala, this approach has proven successful in providing employment for Peace Corps-trained masons.
- Training stove repair and maintenance experts, which can help stoves last longer and create local employment.
- Facilitating the acceptance of improved cookstoves by educating the community about the benefits, arranging for presentations by local entrepreneurs about their products, and helping them access plans to purchase stoves and stove components.

Keep in mind that community members' initial experience with improved cookstoves (ICS) is extremely important. If the first model of ICS introduced (by you or another organization) is of poor quality or for some other reason is not accepted, it may be difficult to re-introduce another, better model later on.

STOVE TERMINOLOGY PRIMER[18]

To work with ICS, you need to understand some basic principles and terminology of stove design. This section provides some basic concepts that can be explored further through consultation with your ICS expert. Please also carefully review the Partnership for Clean Indoor Air's *Design Principles for Wood Burning Cookstoves* (see annexes).

[18] This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 73-76.

Combustion chamber
The combustion chamber is the area of the stove where the fuel is burned.

Combustion efficiency
Combustion efficiency is a measure of how efficiently a device burns fuel—in other words, the percent of fuel that is turned into heat energy by burning. It will vary depending on the design features of a given stove. Stoves that achieve high combustion efficiencies tend to have fewer emissions of pollutants and often require less fuel than those with lower efficiencies. Hot fires burn more cleanly and efficiently, so maximizing combustion efficiency requires consideration of the "three T's": temperature (higher temperature is better), turbulence (turbulent mixing of air and combustible gases is better), and time (air and gases need adequate time to completely combust). Accordingly, factors that affect heat containment and airflow (for example, stove insulation or chimney) can be adjusted in stove designs to boost combustion efficiency.

Heat transfer efficiency
Heat transfer efficiency is the percentage of heat released from combustion that enters a cooking pot. The transfer of heat to the pot through hot gases created by combustion is another important feature of stove design. Improved heat transfer (in other words, keeping hot gases in direct contact with the cooking surface and preventing leakage of heat) is often the greatest factor in reducing fuel consumption. Improving heat transfer efficiency can also decrease emissions if combustion efficiency is maintained. For example, reducing fuel consumption also reduces emissions for a given cooking task, assuming that combustion efficiency remains the same.

Transferring heat to pots or griddles is best done with small air channels, often obtained by optimizing the space below the griddle or pot or by sinking the pot into the hot gases. Small air channels force the hot flue gases from the fire against the pot or griddle. If the gap is too large, the hot flue gases mainly stay in the middle of the channel and do not pass their heat to the desired cooking surface. If the gaps are too small, the draft diminishes, causing the fire to be cooler and the emissions to go up, meaning there is less heat to be transferred to the pot or griddle.

Fuel efficiency
Fuel efficiency (also known as thermal efficiency) is the percentage of the heat energy produced during the combustion of fuel that is used to heat food or water. This differs from *combustion efficiency* in that it measures the amount of energy that is used to do work (i.e., cook food) rather than the efficient breaking down of fuel. Fuel efficiency is a combination of combustion and heat transfer efficiencies. For example, if a typical cookstove has 0.97 combustion efficiency and 0.38 heat transfer efficiency, then fuel efficiency (thermal efficiency) is 0.97 x 0.38 = 0.37.

Air intake and airflow
Air is fundamental to the combustion process, and a consistent flow of air through and out of the combustion chamber keeps combustion hot, clean, and consistent. Airflow around and under the fuel stack is also important for complete combustion. Metal or ceramic grates are often helpful in lifting the fuel off the ground, or bottom, of the cookstove so air can circulate properly.

Chimney

A chimney, usually a vertical structure, is a device attached to a stove to channel smoke from the combustion chamber away from the stove and out of the home. The addition of a properly designed chimney to a stove can greatly increase turbulent mixing of combustion gases, improving combustion and reducing production of smoke, a product of incomplete combustion. A well-designed stove can dramatically reduce smoke production from incomplete combustion without a chimney, but a chimney can improve combustion efficiency if designed correctly.

A chimney helps to pull air through the fuel opening, across the burning fuel, and out of the stove. It is important to balance the dimensions of the chimney in relation to the combustion chamber in order to maximize the benefits. To work properly, chimneys must be kept clean by the user. An incorrectly constructed or dirty chimney can negatively impact stove performance, and even result in higher indoor air pollution than that from an open fire.

TYPES OF STOVES[19]

Stoves can be classified in the following ways, which overlap:

- Fuel burning technology: such as rocket or Top-Lit UpDraft (TLUD), the latter is a type of gasifier design
- Pre-fabricated or fabricated on site
- Materials of construction: mud or clay, brick, fired clay, metal
- Single or multiple burner
- Household or institutional
- With chimney or without
- Intended for use outdoors or indoors
- Fuel type: those presented here are primarily wood, but many other solid fuels are used worldwide, including corn cobs, rice hulls, other crop residues, biomass pellets, biomass briquettes, dung, coal, and charcoal. Charcoal stoves are also mentioned briefly in this section.

Two types of fuel burning technologies are summarized below, followed by special mention of considerations for charcoal and institutional stoves, as background information prior to presentation of a stove comparison matrix and detailed information on stoves most likely to be promoted by Volunteers in communities.

The cookstove technologies and specific models described below are common examples, but the matrix is not comprehensive, and many other technologies exist. For more information, see the wide variety of technologies described on these websites:

http://bioenergylists.org
http://www.hedon.info/Stoves+Database?bl=y

Cookstove technologies continue to evolve, and it is recommended that you assess all of your options.

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[19]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 73-76.

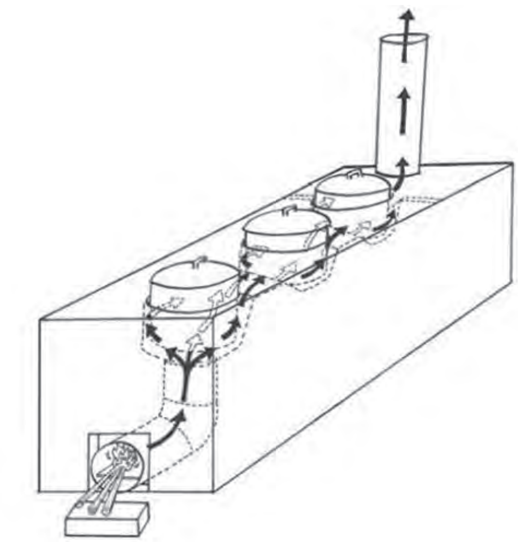

Figure 15: A multiple pot-type rocket stove. *Courtesy of Aprovecho Research Center*

Rocket stoves

Rocket stove design principles focus on achieving efficient combustion and heat transfer by ensuring high temperatures, good draft into the fire, controlled use of fuel and air, and efficient use of the resultant heat. Stoves using rocket principles can be very simple or complex. However, they all include these design components: an L-shaped, insulated combustion chamber; an optimized fuel feed opening to restrict the amount of fuel and air added to the stove at one time; and an optimized gap between the stove and cooking surface to improve heat transfer by forcing hot flue gases to flow against the sides of the pot or griddle. Emissions of rocket stoves range from 35 percent to 65 percent less than a three-stone fire. For further explanation of rocket stoves, see http://www.aprovecho.org/lab/pubs/arcpubs.

Top-Lit UpDraft, TLUD (or Gasifier)[20]

A Top-Lit UpDraft cookstove utilizes a gasifier with a two-stage combustion process in which the wood (or other biomass fuel) inside the fuel cylinder is first transformed into charcoal and gases. The gases move upward to where they mix with fresh (secondary) air and burn with clean high heat for cooking.

Gasifier stoves typically are quick to heat, have high fuel and energy efficiencies, are lightweight and portable, and produce very low levels of emissions when used correctly. Emissions of TLUD stoves are typically 70 percent to 80 percent less than a three-stone fire.

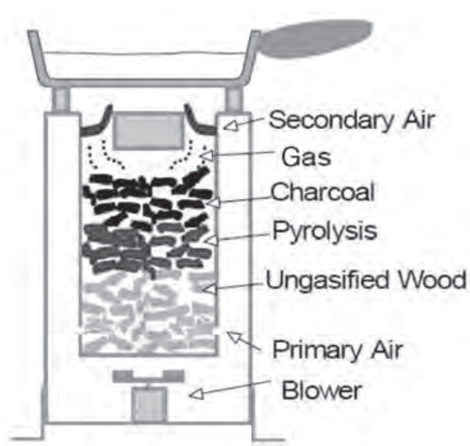

Figure 16: TLUD (or Gasifier) diagram. *Courtesy of Dr. Paul Anderson*

TLUDs can use a wide variety of dry biomass fuels that are usually bite-size or chip-size (including biomass briquettes and pellets) to allow air to move upward through the fuel bed. Success is also reported with vertically inserted reeds and straight pieces of bamboo and wood. This batch operation and top ignition requires some user training, and may have a lower user-acceptability rate. There are many different TLUD stove designs, including some more expensive models with fans to enhance control of the combustion process and to permit use of rice husks as fuel. The "TChar" models place a TLUD T-Top onto an existing charcoal stove (T-Base) so that cooking continues easily on the created charcoal.

An important co-product of TLUD is charcoal that can be used either for further cooking in charcoal stoves (see the TChar description) or as biochar, a carbon-negative soil amendment to help soil retain water and nutrients, and to benefit soil microbes.

[20]Text for this section largely provided by Dr. Paul Anderson, world expert in biogasifier stoves.

Figure 17: Charcoal stove. *Photo courtesy of Aprovecho Research Center*

Charcoal Stoves

Many places in the world use charcoal produced from wood for cooking. Most charcoal stoves are batch loaded (fuel is loaded and lit all at one time) and heat transfer is mostly by radiation (instead of convection, as in wood stoves). For these reasons, the designs often differ significantly from wood-burning stoves. Generally speaking, charcoal is an inherently fuel inefficient method of cooking, as the charcoal is usually produced with a loss of up to 70 percent of the energy in wood from which it is made. Nevertheless, charcoal is valued because it contains more energy per mass than wood (more easily transported) and it is easy to use (requires minimal tending during cooking). Charcoal stoves generally produce little particulate matter, except during ignition, and high levels of CO in use. CO is odorless and can cause death, so it is very important to use charcoal only in well ventilated areas. Design principles for improved charcoal stoves are less developed than for wood-burning cookstoves. For more details on charcoal stoves and the development of improved charcoal stove design principles, visit or contact Aprovecho Research Center at www.aprovecho.org.

Figure 18: Institutional stove (large cylindrical), Nigeria. *Photo courtesy of Aprovecho Research Center*

Institutional Stoves

While the main focus of improved cookstoves dissemination has been on the household stove sector, the institutional setting should not be ignored as an opportunity to make great improvements in a community.

Two keys to fuel efficiency are: (1) having the hot gases touch more surface area of the pot, and (2) having less surface area of the pot or food be exposed to a cooling environment, such as wind. For this reason, the larger the pot the more inefficient the traditional stove usually is and the more efficient the improved stove can be if a good design is used. Improved institutional stoves can be as simple as a large metal or earthen skirt that forces the hot gasses around the pot (a large version of the well-known cylindrical Volunteers in Technical Assistance, VITA stove) or more complex designs that follow the design principles. For more information, visit Aprovecho Research Center at www.aprovecho.org.

SOLID FUEL BURNING STOVE SELECTION MATRIX[21]

This matrix summarizes the basic options of improved cookstoves, categorized by design (traditional, rocket, and TLUD) and materials. Following the table are detailed descriptions of the design and characteristics, pros and cons of each general type of stove, and their maintenance requirements, with emphasis on types typically successfully promoted by Peace Corps Volunteers in their communities. See the reference websites listed in the references and annexes, including the Comparison Table of Stove Information for information on specific stoves.

Stove Type	Materials/ Production	Fuel Type	Cost Range	Pros	Cons	Suitable for
Traditional: Three-stone Fire	Three or more stones or bricks	Wood, charcoal, other	$0	▪ Can accommodate multiple pots as the configuration is flexible	▪ Not optimized for combustion or heat transfer	▪ Not for regular use: not an improved stove
Traditional: mud or clay stoves	Local materials, usually clay or mud	Wood, charcoal, other	$0–$15	▪ Can be used for space heating in addition to cooking for colder climates	▪ Can take a long time to heat up and cook food since the clay typically absorbs a lot of heat ▪ Can be fragile and have limited lifespan	▪ Not an improved stove; normally other options are recommended
Mud or metal skirt stove (VITA)	Local organic materials such as clay/sand/ vermiculite/straw/ sawdust or metal	Wood, charcoal, other	$0–$15	▪ Reduced fuel consumption ▪ Less risk of fires and burns (if built and used properly) ▪ Inexpensive materials	▪ Requires the use of a dedicated pot ▪ Quality control is essential	▪ Use outdoors
Rocket: Mud or clay	Local materials, usually clay or mud, plus metal for chimney and sometimes for griddle and an insulating material to isolate the combustion chamber[22] Can be constructed by users with proper templates and training	Wood, charcoal, other	$0–$20	▪ Reduced risk of fires and burns ▪ Inexpensive materials ▪ Can accommodate multiple pots	▪ Can take a long time to heat up and cook food since the clay typically absorbs a lot of heat ▪ Can be fragile and have limited lifespan ▪ Requires regular maintenance to patch cracks ▪ Unless a mold is used to standardize the design, fuel savings may be lost due to smaller tolerance for error in designs	▪ If used outside, choose either predictably dry regions or places where users will be cooking within a shelter

[21] This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 94-99.

[22] Manufactured in accordance with design principles of wood-burning cookstoves.

Stove Type	Materials/ Production	Fuel Type	Cost Range	Pros	Cons	Suitable for
Rocket: Brick	Fired bricks plus local materials such as clay/ mud	Either wood or charcoal	$30–$100	▪ More durable than mud or clay stove ▪ Takes less time to heat than clay or mud stoves	▪ Fuel savings may be lost due to user modifications ▪ More expensive than mud or clay	▪ Regions where bricks are readily available
Rocket: Ceramic, pre-fabricated	Ceramic, fired in kilns in the country	Either wood or charcoal	$5–$15	▪ Stoves can be portable ▪ Usually more durable than mud or clay stove ▪ Heat up quickly ▪ Pre-tested and high efficiency	▪ Higher cost for same characteristics (number of burners, presence of griddle) as mud, clay, or brick stoves ▪ Prefabricated stoves without chimneys are not designed to be used indoors	▪ Areas where these stoves are available ▪ Transient people or populations ▪ Situations where maximum fuel efficiency is required
Metal, pre-fabricated or ready-to-assemble kits	Metal, sometimes with ceramic liners or grates Higher end models may have fans Models manufactured in country and internationally are available	Either wood or charcoal	$5–$25	▪ Usually more durable than mud or clay stoves ▪ Pre-tested and high efficiency ▪ Ready-to-assemble kits are less expensive (stove and transport) than pre-fabricated, fully-assembled ▪ Usually portable	▪ Most prefabricated metal stoves have only one burner ▪ Metal stoves can pose an increased risk of burns ▪ Metal stoves may suffer corrosion ▪ Higher cost for same characteristics (number of burners, presence of griddle) as mud, clay, or brick stoves ▪ Prefabricated stoves without chimneys are not designed to be used indoors	▪ Transient people or populations ▪ Situations where maximum fuel efficiency is required
TLUD (Top-Lit UpDraft or gasifier)	Usually metal	"Chunky dry biomass" as typified by wood chips, pellets, briquettes, maize cobs, dung chunks, or vertically placed stick-wood and bagasse	$10–$50	▪ Highest efficiency ▪ Usually portable	▪ Difficult to control heat levels ▪ Higher cost for same characteristics (number of burners, presence of griddle) as mud, clay, or brick stoves	▪ Situations where maximum fuel efficiency is required ▪ Situations where biomass is scarce ▪ Situations where processed biomass or agricultural waste is readily available


Figure 19: Three-stone fire.

The Three-Stone Fire[23]

Cost: $0. The baseline against which most improved cookstove models are often assessed is the traditional open or three-stone fire. In a traditional open fire, three stones or similar objects are placed on the ground, with the cooking pot resting on the stones directly above the fire. The open flame and lack of chimney or combustion chamber can make this cooking fire energy-inefficient. In addition, three-stone fires can produce a lot of smoke, contributing to poor air quality and respiratory illness; they also pose a risk of burns from the unshielded fire.

However, the open fire is widely used by households around the world because it: (a) can be assembled virtually everywhere with few resources; (b) can accommodate a variety of pot sizes; (c) costs little or nothing to assemble; and (d) in many places it is what cooks are most accustomed to using. *It is important to note that a skilled cook will require less fuel on an open fire than she or he might with a poorly made or designed "improved" cookstove.*


Figure 20: Mud stove. *Photo courtesy of Aprovecho Research Center*

Traditional mud or clay stoves[24]

Materials: Local organic materials such as clay/sand/mica/straw/grass/sawdust or agricultural waste. Typically the mixture is developed by mixing clay and sand with organic material to hold it together. Dung may also sometimes be added for additional adhesion of materials.

Design: Designs have been developed based on experience and usually are less fuel efficient and more contaminating than other options.

Fuel Source: Wood, crop residues, dung, charcoal.

Cost: $0–$15. Materials and labor are locally available. May use a metal grill.

Advantages:

- Wood fuel or charcoal (with addition of a metal or ceramic grate) can be used
- Less risk of fires and burns (if built and used properly) than a three-stone fire or some other designs
- In colder climates or seasons, can be used for heating living areas in addition to cooking
- Inexpensive materials
- Can be made to accommodate multiple pots

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[23]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMSIN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 71-72.

[24]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 77-80.

Disadvantages:

- Requires regular maintenance to ensure efficiency. Maximum lifespan usually ranges from one to two years, the latter achieved only through extremely diligent maintenance. Maintenance may be necessary on a monthly basis because cracks and crumbling should be patched as soon as they occur
- Can take a long time to heat and cook food, since the clay typically absorbs a lot of heat and reduces fuel efficiency
- Limited portability
- Susceptible to damage from insects such as termites or ants and from weather if used in an unsheltered area
- Stoves often suffer from poor durability

Figure 21: Mud or metal skirt stove (VITA).

Mud or metal skirt stove (Volunteers in Technical Assistance, VITA)

Materials: Local organic materials such as clay/sand/vermiculite/straw/sawdust or metal.

Design: The general design is to create a simple enclosed combustion chamber below a pot and then force the hot flue gasses to pass around the sides of the pot by creating a correctly sized gap for them to pass through. The body of the stove can be either mud (made lightweight by adding organic matter) or thin metal (Figure 21).

Fuel Source: Ideal fuel source is cut, dry wood, but can be designed to burn charcoal, animal dung, or other locally available fuel source.

Cost: $0–$15. Cost will depend on multiple factors, including whether you will need to purchase materials, how far materials will need to be transported, and local labor costs. These stoves are generally very inexpensive to make.

Production considerations: Stoves can be constructed by community members with proper templates and training. However, it should be noted that stoves constructed by people without sufficient training and experience often suffer from poor quality and durability, which can negate any reductions in fuel or indoor air pollution.

Stoves made of mud typically must be left to dry for a period of three days to three weeks before they can be used, depending upon the materials used, humidity, and size of the stove. Using the stoves before they are fully dry will reduce the durability and longevity of the stove, because the materials have not had time to fully cure and harden before being exposed to cooking temperatures. If not cured properly, the stove sides may crumble and crack after a few uses. An ICS expert can advise you on how long the stove will need to dry, and how to determine when a stove has dried completely, taking into consideration the moisture of the clay mixture.

The quality of the clay is an extremely important factor as "weak" clay will crack very fast and make the stove less efficient and undesirable to users. Users can mix the clay with animal dung or other organic materials such as groundnut shells, sugar cane, or rice husks to produce a mixture that will reduce cracking.

A lightweight material such as sawdust is often added to the mud mixture to make the stove more efficient. This will affect durability and needs to be evaluated on a case-by-case basis, but a good starting experimental recipe is one part clay to one part fine sawdust.

For more details, go to www.aprovecho.org.

Advantages:
- Reduced fuel consumption compared with three-stone fire
- Less risk of fires and burns (if built and used properly)
- Inexpensive materials

Disadvantages:
- Requires the use of a dedicated pot. If used with other pots, efficiency will drop considerably
- Deliberate or accidental over-stuffing of the fuel compartment may damage the stove, reducing performance
- Unless a mold is used to standardize the design, efficiency may be lost due to user modifications
- Quality control is essential
- Needs to be used in well-ventilated areas

Training and maintenance:
- Users need to be trained to notice signs of wear in the stove (cracks, crumbling along the edges and stove body, worn or missing pot rests) and how to obtain and prepare materials to mend the stove
- Stove users must be taught not to over-stuff the fuel compartments of the stoves, as this could result in pieces of the stove chipping off and reducing performance
- Because they are made of unfired, organic material, and are often exposed to extreme heat and humidity, mud stoves require frequent, ongoing maintenance

Figure 22: Unfired mud or clay rocket stove. *Photo courtesy of Aprovecho Research Center*

Rocket: Mud or clay (unfired)

Materials: Local organic materials such as clay/sand/vermiculite/ash/straw/grass/sawdust or agricultural waste. Typically the mixture is developed by mixing soil or clay with organic material to hold it together and make it less dense. Dung may also sometimes be added for additional adhesion of materials.

Design: There are many designs that vary in size, number of openings for pots, use of chimneys, etc. Once shaped, mud stoves are dried in the sun over time. The simplest design consists of a rocket combustion chamber and a mud skirt that the pot sits in (shown). The more organic matter added to the mixture the more fuel efficient the design will be, but durability must be taken into consideration.

Fuel Source: Ideal fuel source is cut, dry wood, but can be designed to burn charcoal, animal dung, or other locally available fuel.

Cost: $0–$20. Cost will depend on multiple factors, including whether you will need to purchase clay or dung, how far materials will need to be transported, and local labor costs. These stoves may cost a little more to make than a traditional mud or clay stove if a chimney or grill is included.

Production considerations: Stoves can be constructed by community members with proper templates and training; however, it should be noted that stoves constructed by people without sufficient training and experience often suffer from poor quality and durability, which can negate any indoor air pollution reductions.

Stoves typically must be left to dry for a period of three days to three weeks before they can be used, depending upon the materials used, humidity, and size of the stove. Using the stoves before they are fully dry will reduce the durability and longevity of the stove, because the materials have not had time to fully cure and harden before being exposed to cooking temperatures. If not cured properly, the stove sides may crumble and crack after a few uses. An ICS expert can advise you on how long the stove will need to dry, and how to determine when a stove has dried completely, taking into consideration the moisture of the clay mixture.

The quality of the clay is an extremely important factor as "weak" clay will crack very fast and make the stove less efficient and undesirable to users. Users can mix the clay with animal dung or other organic materials, such as groundnut shells, sugar cane, or rice husks, to produce a mixture that will reduce cracking.

Lightweight materials such as sawdust are often added to the mud mixture to make the stove more efficient. This will affect durability and needs to be evaluated on a case-by-case basis.

Advantages:

- Wood fuel or charcoal (with addition of a metal or ceramic grate) can be used
- Reduced fuel consumption compared with three-stone fire if constructed and used properly
- Less smoke
- Less risk of fires and burns (if built and used properly)
- Inexpensive materials
- Can be made to accommodate multiple pots (with adjustable skirt)

Disadvantages:

- Requires regular maintenance to ensure efficiency. Maximum lifespan usually ranges from one to two years, the latter achieved only through extremely diligent maintenance. Maintenance may be necessary on a monthly basis because cracks and crumbling should be patched as soon as they occur
- Fuel efficiency is low due to heat absorbed by the stove body (rather than the pot)
- Limited portability due to weight and fragility
- Susceptible to damage from insects such as termites or ants and from weather if used in an unsheltered area
- Stove designs in which pots rest within the stove requires a dedicated-sized pot for each stove hole
- Deliberate or accidental over-stuffing of the fuel compartment may damage the stove, reducing performance
- Unless a mold is used to standardize the design, efficiency may be lost due to user modifications
- Quality control is difficult
- If built without chimney, it needs to be used in a well ventilated area

Training and maintenance:

- Users need to be trained to notice signs of wear in the stove (cracks, crumbling along the edges and stove body, worn or missing pot rests) and how to obtain and prepare materials to mend the stove
- Users must also be taught to not over-stuff the fuel compartment, lest they break off a piece of the stove and reduce its performance
- Because they are made of unfired, organic material, and are often exposed to extreme heat and humidity, mud stoves require frequent, ongoing maintenance

Figure 23: Brick rocket stove. *Photo courtesy of Aprovecho Research Center*

Rocket: Brick

Materials: Bricks and local organic materials such as clay/sand/vermiculite.

Design: There are many designs that vary in size, number of openings for pots, use of chimneys, etc.

Fuel Source: Ideal fuel source is cut, dry wood, but can be designed to burn charcoal, animal dung, or other locally available fuel source.

Cost: $30–$100. These stoves will cost a little more to make than a rocket mud or clay stove.

Production considerations: Stoves can be constructed by community members with proper templates and training. However, it should be noted that stoves constructed by people without sufficient training and experience often suffer from poor quality and durability, which can negate any indoor air pollution reductions.

An ICS expert can advise you on construction instructions, tips, and considerations. Go to www.aprovecho.org for construction plans.

Advantages:

- Wood fuel or charcoal (with addition of a metal or ceramic grate) can be used
- Reduced fuel consumption compared with three-stone fire if constructed and used properly
- Less smoke
- Less risk of fires and burns (if built and used properly)
- In colder climates or seasons, can be used for heating living areas in addition to cooking
- Can be made to accommodate multiple pots
- Longer durability than traditional mud or clay stoves

Disadvantages:

- Not portable
- Stove designs in which pots rest within the stove hole limit the circumference of the pots that can be used with that stove
- If the stove is not built with proper insulation between stove body and combustion chamber (as good designs will call for), then fuel efficiency will be low due to heat absorbed by the stove body (rather than the pot)

- Deliberate or accidental over-stuffing of the fuel compartment may damage the stove, reducing performance
- Unless design specifications are followed, efficiency may be lost due to user modifications

Training and Maintenance:
- Users must also be taught to not over-stuff the fuel compartment, lest they break off a piece of the stove and reduce its performance
- As a chimney is a critical part to the functioning of this stove, the user must be trained in the cleaning, repairing, and need for possible replacement of the chimney

Ceramic (kiln-fired)[25]

Materials: Local organic materials—clay/sand/vermiculite/ straw/grass/sawdust/agricultural waste. Similar to the mud stove, ceramic stoves are constructed with clay or soil combined with organic materials. The difference is that ceramic stoves are fired at high temperatures in a kiln for added durability. If your community decides to manufacture these stoves, please see *Fuel-Efficient Stove Programs in Humanitarian Settings: An Implementer's Toolkit,* USAID, in the Improved Cookstoves Training Package references for additional information on kilns. Some development organizations are developing low-emission kilns.

Figure 24: Fired ceramic rocket.
Photo courtesy of USAID

Design: A ceramic-lined combustion chamber covered on the outside with mud for additional stability.

Fuel Source: Ideal fuel source is cut, dry wood, but can be designed to burn charcoal, animal dung, or other locally available fuel source.

Cost: $10–$20. Cost will depend on multiple factors, including whether you will need to purchase clay or dung, how far materials need to be transported, whether you must construct a kiln, local labor costs for kiln operators, and whether you use metal in the design.

Production considerations: Local labor and materials can be used, although skilled producers for kiln firing and drying will be needed. The right mix of organic material needs to be calculated and tested before starting full-scale production. If the mix is incorrect, the stove will be too heavy or too light to fire properly, resulting either in a stove body that is porous and fragile, or too dense, absorbing a lot of heat. In either case, efficiencies will not be maximized. Making and using a mold is a good way to ensure overall design specifications are followed closely, as even small changes in stove design or size can negatively impact stove efficiency and performance. As with all designs, it is important to get construction instructions and work with an ICS expert who has experience with this design.

[25]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 81-84.

With some training, community members can finish the stove by adding mud around the ceramic frame of the combustion chamber. The final mudding lends additional stability to the stove. Mudding also allows the user to personalize the stove with painted images, lettering, or superficial etchings, which can increase user satisfaction with the stove.

Advantages:

- Can use wood or charcoal (with addition of a metal or ceramic grate)
- Stoves can be portable or fixed
- Fairly durable if dried and fired correctly

Disadvantages:

- Requires regular maintenance, not to the same degree as the mud stove, but cracks need to be attended to regularly
- Fuel efficiency may be low if construction material is not insulative due to heat absorbed by the stove body (rather than the pot)
- Deliberate or accidental over-stuffing of the fuel compartment may damage the stove
- Limited flexibility accommodating various pot sizes (depending on design); stoves in which pots rest within the stove hole limit the circumference of the pots usable with those stoves; stoves designed so that the stove rests on top of/over the stove hole allows for greater flexibility
- Unless a mold is used, efficiency may be reduced due to user modifications
- More complicated to produce than mud or clay stoves
- Firing the kiln requires a lot of wood (unless the kiln is a woodless kiln and uses another type of biomass, such as rice husks, to fire the bricks or ceramic cylinders)
- Stringent quality control of the kiln's firing process and the clay mixture is needed in order to minimize breakage and maximize efficiency
- Moderate to low expected fuel and emissions reductions

Training and maintenance:

- Firing the combustion chamber increases the durability of the stove, making it less vulnerable to degradation from weather and heat—most models are still fragile, and the mudded exterior requires maintenance to repair cracks
- Users need to be trained to obtain and prepare materials to repair their stove, and must
    (1) Check for cracks in the combustion chamber, which can occur from faulty materials, dropping the stove, and regular wear and tear. Make repairs as shown in end-user training.
    (2) Patch cracks and crumbling of the unfired, mudded exterior that protects the ceramic combustion chamber.
- Stove users must be taught not to over-stuff the fuel compartments of the stoves, as this could result in pieces of the stove chipping off and reducing performance

Figure 25: Rocket pre-fabricated metal stove. *Photo courtesy of Ecozoom*

Metal, prefabricated or ready-to-assemble kits[26]

Materials: Steel or other heavy metal or sheet metal—new or scrap; sometimes with ceramic liners or grates. Higher-end models may have fans.

Design: Metal, prefabricated stoves include rocket designs and many other designs, such as forced-draft (fan) stoves, natural-draft "gasifier" stoves, etc. These stoves are more expensive than mud or ceramic stoves–perhaps three to 10 times the cost–but typically are more durable and achieve greater efficiency and emissions reductions.

Many commercially manufactured stove models have undergone various types of testing in laboratories. Currently there are no internationally accepted standards for stoves, though this may change in the future.[27] If you are considering purchasing a partially or fully prefabricated stove, you should inquire what type of testing the manufacturer has conducted on the stove. At a minimum, you should look for independently conducted water-boiling tests or controlled cooking tests that calculate thermal efficiency or specific fuel consumption, preferably through a lab associated with the Partnership for Clean Indoor Air or Global Alliance for Clean Cookstoves, included in the list found on this link: http://www.pciaonline.org/testing/stove-testing-centers. Many manufacturers will also conduct tests on emissions (carbon monoxide [CO] and particulate matter with a diameter of 2.5 micrometers or less [$PM_{2.5}$]), and a few labs are developing testing procedures for safety and durability. Ask the manufacturer about its product quality assurance policy, to make certain that it has specifications and processes in place to ensure that its stoves meet those specifications.

Fuel Source: Ideal fuel source is cut, dry wood, but can be designed to burn charcoal, animal dung, or other locally available fuel source.

Cost: $5–$25. Cost will depend on multiple factors, including labor costs for assembly, cost of the stove or stove parts, and shipping and transportation cost to your site.

Advantages:

- Lightweight
- Portable
- Heats up quickly
- Durable
- Little maintenance required
- Can burn wood and charcoal with the proper grate (applies to some models)
- Good designs can achieve very high reductions in indoor air pollution, much higher than typically achieved by mud stoves
- Often perceived as very attractive because they are seen as more technologically advanced or because many models come in different colors and are shiny

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[26]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 5, Pages 85-88.

[27]Organizations, such as the Global Alliance for Clean Cookstoves (http://www.cleancookstoves.org), are in the process of coordinating the harmonization of such standards.

Disadvantages

- Most prefabricated metal stoves have only one burner
- Single-walled metal stoves can corrode quickly if not cared for properly
- Risk of burns if the stove is not insulated to protect against the exterior metal heating up
- Although these stoves usually are more durable than mud or ceramic stoves, corrosion or puncturing of the combustion chamber or stove body, or cracking of the ceramic liner may occur
- Some models may require more fuel preparation or other changes in end-user behavior
- The design of the stove can't be changed post-manufacture, so it must be matched to local conditions, customs, and preferences (e.g., pot size, height of stove) before stoves are purchased

Training and maintenance:

- For manufactured stove kits with ceramic linings (which eventually are likely to crack), users need to be trained to notice signs of wear and how to obtain and prepare materials to repair their stoves
- Stove durability and performance may be affected by lack of replacement parts, such as metal skirts, ceramic combustion chambers, metal grates, or pot supports
- Community members can be trained to repair these stoves as a small business activity, and to provide supplies for maintenance of stoves
- Training must be provided to ensure quality and consistency of parts supplied locally
- Peace Corps staff and Volunteers should discuss all of these issues with the stove manufacturer before purchasing large quantities of stoves

Figure 26: TLUD (Gasifier) stove. *Photo courtesy of Aprovecho Research Center*

Top-Lit UpDraft (TLUD or gasifier)[28]

Materials: Top-Lit UpDraft gasifier (TLUD) stoves are made from steel or other heavy metal or sheet metal—new or scrap. Used cans can be utilized.

Design: These stoves are best if designed by a specialist in TLUD stoves. Designs for household use are publicly available. See the TLUD links to a variety of websites in the references section. See the annexes for a link to a video of a TLUD stove in action.

Fuel Source: The ideal fuel is irregularly shaped wood chips, chunks, or pellets with dimensions of 0.5 x 1 x 2 cm, plus or minus half of each dimension. Sawdust does not work because it settles too compactly for the necessary updraft. Vertically placed straight sticks, bamboo, and reeds work well when the user has some experience. Loose big sticks do not work because there is too much space between them. Rice husks require a small fan in the TLUD unit.

Cost: $10–$50. Low-cost (less durable or smaller) versions can be made or higher cost (more durable) versions can be purchased. TLUDs are becoming available commercially.

Advantages:

- Lightweight
- Portable, but can also provide heat to fixed-location stovetops
- Heats up quickly and maintains constant flame with minimal attention
- Little maintenance required

[28] Text for this section provided by Dr. Paul Anderson.

- Some designs produce a biochar end product that adds value to soil
- Good designs can achieve large reductions in indoor air pollution, and the highest reductions in emissions of any type of wood-burning stove
- May be perceived as attractive

Disadvantages

- Each TLUD unit has only one burner unless a different stove structure (pot support) is used
- Metal stoves can corrode quickly, depending on the quality of material and stove care
- Risk of burns if the stove is not insulated to protect against the exterior metal heating up
- TLUDs require careful fuel preparation and operation, in other words, more changes in end-user behavior than for other stove models
- More difficult to control heat level than in other types of stoves
- The user cannot add more fuel to the unit while it is burning
- Stove shape may be conducive to tipping, especially for large or heavy pots

Operation and maintenance:

- Careful preparation of the starter material is critical for proper functioning of the stove
- The stove is lit from the top and burns through the material over time, depending on the amount and type of fuel pre-loaded in the unit and the flow of air. With practice, the cook will learn to load the stove with the proper amount of fuel required for the cooking task
- To turn the stove off before the burn is complete, the cook needs to remove the combustion unit and dump the hot char into a "snuffer can" (a metal can with a tight-fitting lid)

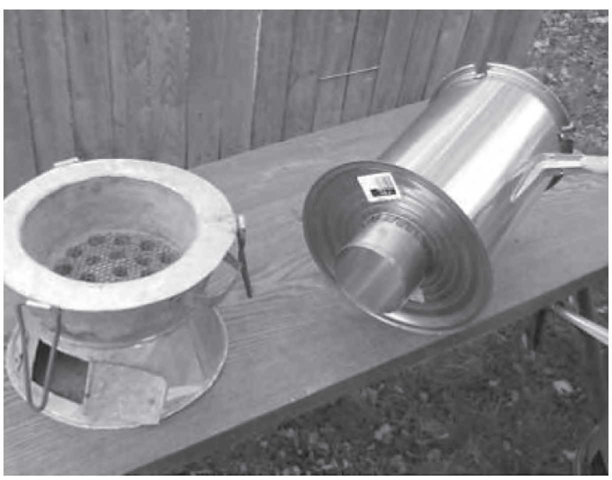

Figure 27: TChar (type of TLUD).

TChar (a special TLUD gasifier stove)[29]

Most of the description of the standard TLUD gasifier stoves applies to the TChar units. However, the TChar designs have a TLUD top (or T-Top) that fits onto an existing charcoal stove as its base. After the fuel is spent, the T-Top is lifted straight up and the created charcoal remains in the fully functional charcoal stove that the family normally uses. Because the TChar stove uses dry biomass fuels and creates its own charcoal for the charcoal stove, there is no need to purchase traditionally made charcoal. Documentation of "TChar Technology for Cookstoves," including instructions for fabrication and a Peace Corps workshop in Honduras, can be found at www.drtlud.com.

[29] Text for this section provided by Dr. Paul Anderson, with minor modifications.

Volunteer Improved Cookstove Activity Design and Implementation

The sustained value of improved cookstoves—not only for families within the community where a Volunteer lives, but also for other communities in the region that may in the future replicate the efforts—will be strongly affected by the quality of activity assessment, planning, implementation, monitoring, and evaluation. This section includes a summary of tasks that Volunteers undertaking improved cookstoves projects should perform, followed by guidance related to those tasks.

VOLUNTEER TASKS

Volunteers undertaking an improved cookstoves project with their partner(s) are expected to do the following:

- **Learn** more about improved cookstoves and experiences with different types of stoves in their country of service, including learning about current efforts in the community, region, and country to promote improved cookstoves.
- Conduct an **initial assessment** to answer at least:
  - What are current practices, and what do people currently invest (time and money) in fuel?
  - What are current needs and preferences, and what would cooks like in an improved stove? For example, some cooks feel that smoke is a benefit because it keeps insects away. On the other hand, many cooks are bothered by the accumulation of soot on pots and walls and see the potential of reduced soot as an advantage of an improved cookstove.
  - Which partners and programs does it make sense to work with, both programmatically and based on demonstrated interest?
  - Do community members have sufficient need, willingness, and resources to pay for available cookstoves, or should you and your partner not engage in an improved cookstoves activity?
- **Acquire and use the stove models that you will likely promote.** These should match the desired stove characteristics from your assessment and the Peace Corps stove criteria (Page 4). You will likely begin with models that your post is promoting, or that other recognized development organizations are promoting. Based on your experience, you may decide to select other stove models, and you should be able to help others select and properly use their stoves.
- **Identify partners** to work with.
- With a partner or partners, **develop an implementation plan.** The plan should:
  - Involve at least one local, regional, or national partner organization or institution in the planning, implementation, ongoing support, and evaluation phases.
  - Secure local government cooperation and support.
  - Include a communications component to promote interest in improved cookstoves.
  - Include stove testing as appropriate. At a minimum, baseline and impact fuel use with one of the standard stove test methods should be included. If stove models that have not been tested or that have been modified are to be promoted, testing should be carried out to ensure that the stoves meet the Peace Corps stove criteria.
  - Include development of behavior change strategies and elements.
  - Build capacity and promote appropriate stove-maintenance behaviors. Volunteers and their partners may choose to promote changes only in kitchen and fuel management behaviors and may decide not to promote installation of improved cookstoves.
  - Empower families with information to make the most appropriate stove-option decisions: cost, emissions, health benefits, durability, and fuel efficiency, and avoid promotion of stove solutions that require significant subsidies (more than $50 per family).

    - Address financing and promote financing arrangements that can be replicated with local resources by others. Promote family payments of stoves in installments or microfinance, if needed.
    - Promote other behaviors known to reduce pneumonia, including immunizations for all children aged 5 and younger.
    - Locate or train local artisans; involve local artisans, masons, carpenters, bricklayers, or welders in the project.
    - Address technical support issues.
    - Include a monitoring and evaluation component.
- **Promote interest** in improved cookstoves.
- **Conduct baseline kitchen performance tests.**
- **Implement** the plan.
- **Monitor** progress, provide refresher trainings as needed, perform mid-implementation stove performance testing, and make any needed adjustments discovered.
- **Report** outputs (i.e., the number of people trained, number of stoves built).
- **Evaluate results.**
- **Report** outcomes and any lessons learned.

INITIAL ASSESSMENT

Every activity should begin with an assessment that helps the Volunteer develop a clear understanding of: 1) the current context; 2) the advantages and disadvantages of the context; and 3) any gender considerations that impact the context. The Volunteer should identify and motivate potential partners and learn about any similar efforts that have been successful or unsuccessful in the community or in neighboring areas.

Some improved efficiency stove programs have failed because the options chosen did not meet the needs or preferences of women and other users in relation to the number of pots typically used at a time, the availability of a grill for frying, preferences for cooking indoors or outdoors, user preferences for portable or fixed stoves, or user needs related to cooking time. The best improved cookstove programs do not assume a one-size-fits-all approach, but offer users an array of options. Not all users have the same needs and preferences, even within the same community.

The initial assessment may also lead you to the conclusion that an improved cookstove project is not appropriate for you to undertake with your community. For example, if the answer to all of the following questions is "no," then an improved cookstove activity may not be a priority need in your community:

- Is visible indoor smoke present in most kitchens, to the extent that being present during a cooking period causes you to cough, or your throat or eyes to burn?
- Is the local fuel supply or its access limited?
- Do families spend a significant portion of their time or monthly budget on fuel?
- Are fuel collectors at risk of abuse, attack, or exploitation?

The **Peace Corps Baseline Survey on Community and Individual Cooking Fuel Use and Preferences** (see annexes) includes two parts:

- **A community leader interview,** which identifies communitywide information, such as fuel costs and organizations that are working in the community. You may have already included some of this information in your community assessment work for your primary project activities. A stakeholder discussion group may be a good way to gather much of this information.

- **A household survey** to determine current knowledge, practices, concerns, and preferences, which may vary from household to household. Observations of house and kitchen characteristics are also included in the survey.

Prior to deciding whether to begin a project, Volunteers should interview at least two community leaders, two health center representatives, and 10 families in the community. Once the decision has been made to move forward with a cookstove project, in most cases, Volunteers are working within small communities and can survey all of the households that have interest in participating in an improved cookstove program. However, in cases where Volunteers are working within larger communities or are supporting larger programs, a random sample methodology should ideally be used to select survey participants, to ensure a representative sample. See *Fuel-Efficient Stove Programs in Humanitarian Settings: An Implementer's Toolkit,* USAID, available as indicated in the references section with the Peace Corps Improved Cookstoves Training Package or on the Internet, for further guidance on random sampling for cookstove projects. Another resource is WHO's *Evaluating household energy and health interventions: a catalogue of methods* (see annexes).

IDENTIFY PARTNERS

As with any other endeavor a Volunteer undertakes, collaborative, enthusiastic local partners can make all the difference.

Local partners that may be interested in engaging in this issue include:

- The municipality
- Local government extension agents promoting rural development
- The health post and organizations promoting improved health
- Schools
- Women's groups
- Environment groups
- Military groups (a Volunteer in Bolivia engaged enthusiastic military personnel to assemble and install stoves)

In addition, Volunteers should be sure to contact representatives of development organizations promoting improved cookstoves, as well as certified providers or manufacturers of improved cookstoves. Take advantage of the experience these organizations have.

STOVE FINANCING

Early in the project development phase, you and your partners will need to select the types of stoves to promote. It is important to promote solutions that are affordable to the families served, yet also appropriate to meet the user needs and the desired health and emissions outcomes. In most cases, users will appreciate a range of choices, and families within communities will have a range of needs and abilities to pay. For example, one mother in Honduras preferred a portable stove to a fixed stove because she was planning on moving within a year to be closer to her son.

Where possible, a partially or fully commercial approach should be used. ***Research indicates that participants who pay for their stoves, even if it is only a nominal fee, are more likely to replace broken components and value and maintain them better than if they receive them at no cost.*** Making every effort to have users pay for all or part of the cost of their stoves will increase the sustainability of an improved cookstove program or activity.

While most rural families will likely not have enough funds in savings to pay the full cost of a stove from one day to the next, your implementation plan should consider financing options such as:

- Savings plans. Volunteers in El Salvador have worked with community members to save money over a period of six to 12 months to be able to purchase a relatively low-cost stove. In the case of El Salvador, the cost of the stove model promoted in this way was US $40.
- Subsidized microfinance model. Such a model was used by Energy4everyone in Accra, Ghana, in the Adabraka Fish Market energy efficient cookstove project. Energy4everyone partnered with a local microfinance institution to provide loans to fish market vendors to purchase cookstoves. In this type of partnership, the cookstove funder provides the grant or cash collateral to the microfinance institution. The microfinance institution provides the loan fund management expertise. Providing the loan fund for this particular venture creates an incentive for the microfinance institution to manage the cookstove loan fund program, as they will receive interest on the loans issued and have access to additional capital for lending. It is always a good idea to partner with an experienced microfinance institution to manage the loan fund. The microfinance institution can screen clients and manage the disbursement and repayments of the loans. Depending on the arrangement with the microfinance institution, once the loans have been repaid, the loan fund capital might be returned to the funder in order to do a similar cookstove project in another location.
- Community banking. This model organizes community members into a self-managed savings and loan association. In this model there may not be an external loan fund from a microfinance institution. Instead, the loan fund is generated by the members themselves. Members of community banks save regularly. The savings is then pooled and lent to members in the bank who pay interest on the loans. The interest is then paid back to members as dividends in proportion to their savings. In this model, individuals could either use their accumulated savings to purchase a stove or take out a personal loan from their community bank and pay it back with interest.
- Micro-consignment. Volunteers in Guatemala have promoted cookstoves through the micro-consignment system for stove parts (for example, the griddle or the chimney) or portable stoves that are purchased, not built, where support systems for this model exist. In this model, a supplier of portable stoves or stove parts lets a seller keep the item in stock without paying for it until it is sold. Micro-consignment is a social enterprise approach that applies the consignment model so small entrepreneurs can start businesses with lower initial costs.
- The Merry-Go-Round. There are many types of rotating savings and credit associations. A simple type is the Merry-Go-Round. In this savings mechanism, a group forms and agrees to contribute a set monetary amount that is made daily, weekly, or monthly by all members. On a rotating basis, one member receives the lump sum of all contributions for that day, week, or month. Provided the sum is large enough, the person receiving the lump sum would have enough money to purchase a cookstove. The group needs to be large enough so the savings amounts are reasonable for the individual to contribute and provide a substantial lump sum, and yet small enough to ensure a high level of trust, since each member is obligated to bring his or her contribution until the cycle is complete and each person has received a lump sum payment. At that point, the group can choose to disband or continue. This model requires little or no bookkeeping, other than to keep track of the order in which members are to receive their lump sum payment.
- Linking up with carbon credit financing programs. These are likely not currently available in most Peace Corps countries, but if they are, they can be a great financial resource for improved cookstove programs, providing financing for as much as $50 per stove. Country experts in improved cookstoves would know if negotiations are ongoing regarding cookstove programs in the country. An example is the model developed for cookstoves in Peru by Microsol. See the references and annexes for links to websites for information on carbon credit financing and on this model.

In addition, Volunteers with partners may seek outside sources of funds to help keep the cost of stoves down. Ideally, these outside sources should be replicable, such that Volunteers are not promoting an isolated handout solution, but rather a model that could be adopted by neighboring communities. For example, a local municipality may designate a portion of its annual funds to a cookstove project.

MICROENTERPRISE DEVELOPMENT

A good way to implement an improved cookstoves project is to approach it as a microenterprise development project. Training ceramicists, masons, or bricklayers to build and install improved cookstoves can diversify their skills and create a new source of income for local professionals. This way of approaching the project is beneficial for a few reasons. First, it ensures that the project is truly "owned by the community." Locals will decide by themselves exactly how to implement the project because after completing the training, they carry out the responsibility of managing the construction or sale of the improved cookstoves. Second, it ensures greater sustainability of the project because the project focuses on capacity building for local professionals and is not dependent upon outside sources of income.

PROMOTION: SPREAD THE WORD!

Cookstoves programs are most effective when their implementation includes a promotion campaign to instill wide interest and demand for the new cookstoves. Education about the environmental and health benefits of improved cookstoves will encourage community members to participate, although it should be noted that experience has shown that time and cost savings tend to be stronger motivators for stove adoption than health or environmental benefits. Each community is different, and assessing what motivates stove adoption should be part of your implementation plan; social marketing and behavior change messages should then be developed around the findings.

Ways to promote a cookstove project:

- Fairs and stove demonstrations
- Radio
- Slogans
- Posters
- Key community members as spokespersons
- Ads in local dialect/language
- Photos
- Web
- Television
- Jingles
- Socio-dramas

An important part of the initial stage of an improved cookstoves project is to get the word out and get the community talking about it. Media sources such as radio and television are a good way to reach a lot of people at a minimum cost. Some ways to use media include:

- Discussions of new cooking technologies and ways to save fuel.
- Weekly programs that address aspects of new cookstoves, including health and environmental messages.
- Demonstrations of using new methods (such as solar) or new cookstoves.
- Interviews and videos of people showing off their new cookstoves.
- Socio-dramas. A socio-drama is a play in which several individuals act out assigned roles as a method for exploring the conflicts and issues.

A Volunteer in Bolivia found the local radio and television stations to be extremely helpful for advertising cooker demonstrations, in addition to notifying the community members of payment deadlines. As a result of the enthusiastic interest shown during the demonstrations by the community, the local government decided to get involved by subsidizing the wood-burning stoves and solar cookers promoted during the project. In total, 150 cookers were installed at her site, including two institutional cookers for the school lunch program.

Other promotion considerations:

- If the community has a local newspaper or periodical, articles and pictures of the project can help promote it and involve partners and young people in writing and photographing.
- If the cookstoves project involves looking for external funding, include the costs of launching an ad campaign.
- If Volunteers are going to be involved with radio or television broadcasts, or publishing, they must seek approval from their associate Peace Corps director (APCD) and refer to the *Volunteer Handbook* for official rules and regulations.
- **Involving schools:** Children who participate in activities with the new stove or oven will go home and talk to their parents about what they did in school, helping to spread the word about the project.

Demonstrations and Practice Cooking Sessions[30]

Cooking demonstrations at public sites such as markets, schools, community centers, and places of worship to disseminate information about stoves and their benefits over traditional cooking methods can generate interest. Community members may be invited to taste and share the food cooked and comment on features of the new cooking methods, such as use of fuel or the amount of smoke generated compared with those factors in a traditional stove or open fire.

Providing cooks the opportunity to give the new technology a "test drive" before deciding whether or not they would like to install one in their own homes or before deciding which model to install is an approach that development workers have used successfully with improved cookstove programs. Demonstration units can also be used as an educational tool for a discussion about environmental issues, such as deforestation or erosion, or such health issues as the amount of smoke emitted. Including music, skits, or other cultural activities in public demonstrations helps to generate more interest.

Capacity Building and Behavior Change

The heart of any Volunteer activity is capacity building, with an ultimate aim for changed behaviors. As Volunteers and their partners plan promotion and outreach efforts, they have to consider behavior change concepts and strategies. Designing for behavior change involves understanding gender roles and conducting surveys to determine why people adopt or do not adopt certain behaviors, and addressing those factors with awareness-raising, training, and behavior change support.

For example, behavior change activities and communication efforts of Volunteers and partners will involve:

- **Raising awareness** of the benefits of improved cookstoves so community members ***decide to acquire*** an improved cookstove. For example, explain the potential health effects of indoor air pollution, especially on children. Or, explain the potential benefits of using an improved cookstove and perhaps a retained heat cooker in terms of health, environment, and personal finances.
- Helping community members ***select and finance*** the best stove for their situation. Personalizing a stove can create a congenial atmosphere and instill pride in ownership of the stove that can

[30]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 10, Page 155.

Figure 28: Example of a stove that has been personalized with a ceramic exterior. *Photo courtesy of Agua, Arboles y Pueblo, El Salvador*

Figure 29: Community promoter of improved cookstoves, Honduras.

have a positive influence on the way recipients maintain and use their stoves. Ensure, however, that these personalized touches do not negatively affect the operation of the stove. For instance, households might paint or draw on them, add a ceramic finish, or add the family name on a stove.

- Helping community members ***properly use and maintain*** their stoves, as the stoves may differ from their traditional way of cooking. For example, provide training or individual instruction to new stove users on how to use their stoves safely, including specific guidance on what not to do with a new stove, etc. They will need guidance on improved kitchen and fuel management, and how to maintain—and perhaps repair—the stove. In some communities, the men will always be responsible for climbing on the roof to clean stove chimneys, while in others women will perform that task, so training and guidance need to support the appropriate groups.
- Encouraging community members to ***continue using*** their new stoves, helping them to change certain habits, adopt new habits, and address any issues that arise from using such stoves. Users of improved stoves, such as Doña Delfa Lagos in Honduras (Figure 29), serve as excellent advocates for changed behaviors. A strategy used by one Volunteer to support continued use of stoves was to require community leaders to exclusively use the new stoves for a two-week period and to share their experiences.
- Helping community members to **adopt other practices that reduce the health risks of cookstoves and reduce child mortality** and morbidity due to pneumonia or other respiratory ailments. This can be done by integrating messages with concepts of healthy homes or kitchens that include water and sanitation behaviors (e.g., messages about safe water storage, hand-washing, and appropriate disposal of feces).

Working with health promoters[31]

Public health facilities, such as health clinics in rural areas, often develop and implement health extension programs for community education. The programs include classes, workshops, or demonstrations in local fairs on the most urgent health issues in an area, such as nutrition, prenatal care, childhood morbidity from exposure to indoor air pollution, and proper water-treatment procedures.

[31]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 10, Page 155.

A Volunteer could partner with a local medical facility to create an outreach program for improved cookstoves that focuses on educating community members on the health benefits of reducing their exposure to indoor air pollution. The Volunteer should ensure that a community member, possibly someone who works directly within the health institution, is trained as an expert in the construction, operation, and maintenance of the models of cookstoves promoted and installed in the community.

All partners who are promoting improved cookstoves and the requisite changed behaviors need sufficient training so they can, in turn, appropriately train community members. Volunteers and partners together can set learning objectives for themselves and for the community members whom they will support. They must know the technical operating principles of the stoves they are promoting and the rationale for choosing the selected stove models. Volunteers and partners should have experience using the stoves effectively themselves. Ideally, they will have completely mastered the use of the stoves and will be able to answer any questions from the community members.

New stove owners should have initial stove training, with a planned series of follow-up household visits (the first within one week of the training), complemented by public demonstrations. Research in development contexts shows that enabling—and persuading—community members to use their new stoves to their fullest potential requires a considerable investment of time. During any training or demonstration, all participants—women and men—should be made to feel comfortable enough to ask questions. One of the many reasons it's key to involve both women and men in the training is that while women may be the most obvious ones who stand to benefit from an improved stove, men often have the decision-making power for purchases within the household.

It is important to balance verbal instructions with visual tools and demonstrations, as well as with hands-on practice with how to prepare fuels or tend the fire, ensuring that your key messages will be imparted successfully—and community members will feel confident in their skills and be convinced that they should change their behavior.

Visual Tools[32]

One method to help people remember how to properly use and maintain new stoves can be to create drawings and posters that provide simple visuals of the do's and don'ts of stove use. They can be a useful and popular way to educate community members. See the one-page Nicaragua *Manual de Usuario Biodigestor* and the *Fuel-Efficient Stove Programs in Humanitarian Settings: An Implementer's Toolkit,* USAID, on the Internet for sample visual tools that have been used to demonstrate stove maintenance and use.

[32]This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 10, Page 144.

ANTICIPATING COMMON PROBLEMS[33]

The following table shows common problems faced by ICS programs and ways you can reduce the chances that they will occur.

Risk/problem	Impact	Ways to mitigate risk
Inconsistent quality of stoves produced	▪ Ineffective product ▪ Disinterest/distrust of community members	▪ Be sure that those constructing stoves receive adequate hands-on training, including practice with building at least two stoves with supervision ▪ Use molds and measures to standardize the product ▪ Provide periodic follow-up training to reinforce skills ▪ Implement quality control practices
Poor quality of raw materials	▪ Ineffective or rapidly deteriorating stoves ▪ Disinterest/distrust of community members ▪ Increased costs if materials must be brought from farther away	▪ Select your stove model according to the resources available in your area ▪ Implement quality control practices
Reluctance of community members to change behavior	▪ Improper stove use or limited use of new stove ▪ Fuel savings will not be achieved	▪ Be careful about stove selection and involve the community ▪ Demonstrate stove benefits before and during project implementation ▪ Involve community leaders and enthusiastic stove users as early adopters to help promote the use of ICS
Improper stove use	▪ Fuel savings will not be achieved ▪ Emissions reductions won't be realized ▪ Stoves could be damaged	▪ Conduct ongoing training and follow-up visits ▪ Use behavior change techniques, including ideas listed in this section

[33] This sub-section adapted with permission from *FUEL-EFFICIENT STOVE PROGRAMS IN HUMANITARIAN SETTINGS: AN IMPLEMENTER'S TOOLKIT, USAID, June 2010,* Step 7, Pages 115-119.

Monitoring, Testing, and Reporting

The ultimate goal of an improved cookstove activity program or project is that the community members correctly and regularly (and ideally exclusively) use the improved stoves/ovens, thereby improving their families' health, decreasing their use of firewood, and decreasing greenhouse gas contributions. If a new stove model is promoted, adjustments may need to be made to the stove design to resolve technical issues and issues related to user preferences. Users may need to adopt and maintain new kitchen management and stove maintenance behaviors. Well-designed and executed monitoring and evaluation activities will contribute to the success of cookstoves programs.

The Peace Corps has established four agency indicators for improved cookstoves:

- **Energy Consumption-Cookstoves:** Number of individuals, out of the total number of individuals the Volunteer/partner worked with, who lowered their consumption of fuel wood or charcoal through the use of a new or improved cookstove.
- **Cookstoves Purchased or Constructed:** Number of cookstoves (new or rehabilitated) purchased or constructed for households or institutions (e.g. health clinics, schools) with assistance of Volunteers or partners.
- **Households Using a Properly Maintained Improved Cookstove:** Number of households having a properly maintained improved cookstove that is being used for at least 90% of household cooking needs.
- **Individuals Benefitting from a New or Rehabilitated Cookstove:** Number of individuals living in households benefitting from new or rehabilitated cookstoves.

These indicators should be included in the Volunteer reporting tool as primary or secondary indicators by all posts where Volunteers have in the past promoted, or are expected in the future to promote, adoption of 100 or more improved cookstoves or ovens per year.

Posts are welcome to establish other indicators, and Volunteers are encouraged to take a broader look at monitoring and evaluating their projects. For example, posts and Volunteers may want to determine whether families are exclusively using their improved stoves (versus using both the improved stove and traditional stove for different tasks or in parallel). Posts and Volunteers are encouraged to evaluate any other benefits that users perceive from the adoption of their improved cookstoves and to gather information that might reasonably be related to the adoption of the improved cookstoves. While health benefits are difficult to quantify without extensive epidemiological studies, there are often ways of determining nonstatistical indications. For example, one returned Volunteer documented a decrease in complaints of eye irritation.[34]

Every post must ensure that any cookstove that Volunteers promote meets the Peace Corps minimum criteria for improved cookstoves, including that stoves (a) consume at least 35% less fuel when cooking a typical meal than the traditional stove currently in use (b) achieve a reduction in air contamination by use of a chimney for indoor stoves , and where data is available or can be obtained, achieve at least a 90% reduction in emissions or exposures , as confirmed by either a standard controlled cooking test or a kitchen performance test conducted in the country.

To meet these criteria, posts and Volunteers may choose to promote a stove that has been tested by another organization, to have their stove tested by a stove-testing center, or to test their own stoves.

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[34] Redman, Aaron. "Transitioning towards Sustainable Cooking Systems: With a Case Study of Improved Cookstoves in Rural El Salvador." Thesis Paper, Arizona State University, August 2010.

Find information on stove-testing centers in or near your country on the Global Alliance for Clean Cookstoves website.

There are three standard tests for determining the fuel efficiency of improved stoves:

- **The Water Boiling Test (WBT).** This lab-based test is most appropriate for those manufacturing stoves or adapting stove designs. It can be used to determine fuel efficiency, the ability of a stove to reduce to low power, the time it takes to boil water, and emissions.
- **Controlled Cooking Test (CCT).** This test involves local cooks preparing a local dish. Adding the inherent variables of this method limits comparability of results to a given setting, but provides important feedback as to the likely acceptability of a stove by local users.
- **Kitchen Performance Test (KPT).** While this test has the most variables (see disadvantages in the following table), it is the best test for determining the field-based results of stove use. It consists of a survey and a fuel-consumption test with families using both the traditional and the improved cookstove. The test gives results of user satisfaction and per capita fuel consumption for a given stove.

	The Water Boiling Test (WBT)	**The Controlled Cooking Test (CCT)**	**The Kitchen Performance Test (KPT)**
What is measured?	How much fuel is used to boil and simmer a specified amount of water under fixed conditions	A trained community member prepares pre-determined meals in a specified way—measures stove performance in comparison with traditional cooking methods	How much fuel is used in actual households when cooking normally over a few days
Technical Objective	To determine how much of the available heat is delivered to the cooking pot when water is heated	To compare the specific fuel consumption (grams of fuel per kilogram of food cooked)	To calculate the amount of wood the family used per day
Test setting	Controlled, lab-based environment	A controlled setting using local fuels, pots, and practice	To be performed by Volunteers in the field; real-world settings
What can the test track?	The effect of changes in stove design, fuel quality, and other physical variables	It reveals what is possible in households under ideal conditions	KPT is designed to assess actual effects on household fuel consumption
Advantages	The test is short; results are not highly variable, relatively few tests can give useful and quick feedback Easiest, quickest, and cheapest to conduct	Requires cooking only one type of food (though testers are encouraged to prepare a combination of foods, if more extensive testing seems important)	Typically conducted in the course of an actual stove dissemination effort and normally gives the best indication of real-world changes
Disadvantages	Not an accurate way to determine actual fuel use under field conditions or changes in fuel use	Cannot necessarily track what is actually achieved by households during daily use; tests from different places can be compared only if the pot, wood, and operation of the stove are the same, which is unusual	A lot of confounding variables: holidays, visitors, use of other stoves, ventilation, fuel supply, etc.

Adapted courtesy of PCIA from http://www.pciaonline.org/testing

Standard protocols for these three tests are included with the Peace Corps Improved Cookstoves Training Package on the Intranet or on the Internet, as indicated in the references section of this handbook. For all three tests, special equipment is required. The equipment is a scale with a capacity of at least six kilograms with an accuracy of ±1 gram, and a digital thermometer, accurate to $1/10^{th}$ of a degree, with a thermocouple probe suitable for immersion in liquids. Optional additional special equipment include an air quality meter for measuring particulate matter and carbon monoxide, and a wood humidity meter.

Ideally, posts will purchase the minimum equipment necessary to conduct the tests, and any Volunteer promoting improved cookstoves for 30 or more community members will conduct a kitchen performance test with at least five families with traditional stoves prior to adoption of improved cookstoves and with the same five families after adoption of improved cookstoves (baseline and impact fuel use).

The results of the standard stove performance tests can be used to estimate reductions in fuel use and emissions—in other words, quantifying the environmental benefits and the reductions in health risks.

Training Volunteers

Many posts with Volunteers who promote adoption of improved cookstoves have not incorporated promoting cookstoves into any of their project plans. Improved cookstoves are often promoted as secondary activities, supporting the work of Volunteers in health, environment, agriculture, and business projects. Therefore, it is appropriate to include in pre-service training (PST) only an introduction to cookstoves, and to conduct a more intensive cookstove training activity as an in-service training (IST) only for Volunteers who have identified that there is an interest in improved cookstoves in their communities.

Figure 30: Volunteers at a cookstoves training workshop, Nicaragua.

Please refer to the Peace Corps Improved Cookstoves training package, a companion piece to this handbook, for detailed learning objectives and session plans for improved cookstoves designed for trainees in PST and for Volunteers and their partners in IST. This training package also includes resource annexes shared with this handbook. Staff and Volunteer leaders can find the Improved Cookstoves Training Package on the Focus In/Train Up Intranet site.

In summary, these are the sessions included in the improved cookstoves training package:

Session number	Most likely to be used for	Recommended session duration	Session Title
1	PST	1 ¾ hours	Introduction to Improved Cookstoves
2	PST	3 ¼ hours	Initial Assessment
3	IST or ongoing learning	3–14 hours	Improved Cookstove Construction
4	IST or ongoing learning	3 ¼ hours	Standard Cookstove Performance Tests
5	IST or ongoing learning	2 hours	Cookstove Activity Planning
		Total: 13–25 hours	

While the training package sessions are designed as formal training sessions, it is expected that a large number of Volunteers benefiting from this handbook and the training package will be using them as ongoing learning references. For example, be sure to take the *Improved Cookstoves Quiz* at the end of the Peace Corps Improved Cookstoves Training Package to determine the extent to which you have learned key concepts about improved cookstoves, and check your answers with the quiz answers given in the corresponding sessions of the training package.

Annexes and References

SHARED ANNEXES WITH THE COOKSTOVES TRAINING PACKAGE

All of the following resources can be found with the Peace Corps Cookstoves Training Package, while most can also be downloaded from the Internet.

Name	Website
Peace Corps Volunteer Cookstoves **Baseline Survey**	
Comparison Table of Stove Information	The Peace Corps K4 health site http://www.k4health.org/toolkits/improvedstoves
Guide to Designing Retained Heat Cookers (English and Spanish)	http://www.pciaonline.org/resources
Design Principles for Wood Burning Cookstoves (English, French, and Spanish)	http://www.pciaonline.org/resources
Solar Cooker Technical Reference Materials and links	
Fuel-Efficient Stove Programs in Humanitarian Settings: An Implementer's Toolkit, USAID	http://www.k4health.org/toolkits/improvedstoves/fuel-efficient-stove-programs-humanitarian-settings-implementer%C3%A2%E2%82%AC%E2%84%A2s-toolkit
Cooking with Less Fuel: Breathing Less Smoke, Aprovecho Research Center	www.aprovecho.org/lab/pubs/rl/stove-design/doc/114/raw
Water Boiling Test	http://www.pciaonline.org/testing
Controlled Cooking Test	
Kitchen Performance Test	

OTHER REFERENCE MATERIALS AND WEBSITES

Name	Website
Micro-gasification: **Cooking with gas from biomass, GTZ** **TLUD video** TLUD website	http://www.gtz.de/de/dokumente/giz2011-en-micro-gasification.pdf http://www.youtube.com/watch?v=SaeanoWZE7E www.drtlud.com
Here Comes the Sun: Options for Using Solar Cookers in Developing Countries	www.giz.de/hera

Name	Website
PCIA Bulletin #26: **LPG**	http://www.pciaonline.org/bulletin/pcia-bulletin-issue-26
Aprovecho Research Center: Resources and consulting services on stove benchmarking, testing, training, and evaluation.	http://www.aprovecho.org/lab/index.php
Bioenergy Listserv: A listserv that serves as an information and communication center for those working on or with biomass stoves. Extensive information on various stove designs and technologies.	http://www.bioenergylists.org/
GIZ: Provides information on technologies, program implementation, and case studies. Program for Basic Energy and Conservation in Southern Africa **(PRoBEC)** and **HERA** (Household Energy for Sustainable Development).	http://www.probec.org and http://www.gtz.de/en/themen/12941.htm
HEDON Household Energy Network: A user-driven site that serves as a resource and communication center for those working on household energy issues.	http://www.hedon.info/
Partnership for Clean Indoor Air (PCIA): Information includes a publication on design principles for stoves, case studies, and guidance on stove design and performance.	http://www.pciaonline.org/
World Health Organization: Provides a number of studies on indoor air pollution and cost-effectiveness of various household energy interventions, including **Evaluating household energy and health interventions: a catalogue of methods**	http://www.who.int/indoorair/en/ http://www.who.int/indoorair/publications/methods/en/index.html
Solid Fuel Household Cook Stoves: Characterization of Performance and Emissions, James Jetter, and Peter Kariherb, 2009	http://www.pciaonline.org/node/904
Carbon Finance: a guide for sustainable energy enterprises and NGOS: Provides a general guide for how entrepreneurs should consider carbon finance in their business plans, and how to first assess their business's potential. **Microsol example, Peru:** A summary of the mission, contact information, focus, and experience of the Peru-based social business, Microsol, as well as its relationship with the Partnership for Clean Indoor Air.	http://www.gvepinternational.org/en/business/guides (first link) http://www.pciaonline.org/microsol-0

INTRODUCTION TO IMPROVED COOKSTOVES QUIZ

The following is a self-assessment quiz you can take to see if you captured key facts and issues related to improved cookstoves. For the answers, you may refer to the text of this handbook, or the Improved Cookstoves Training Package.

1. ***How many children under age 5 worldwide are estimated to die from indoor air pollution each year?***

   a. 50,000
   b. 90,000
   c. 450,000
   d. 900,000

2. ***What is the goal set for adoption of clean and efficient stoves by the Global Alliance for Clean Cookstoves?***

   a. 1 million homes adopt clean and efficient stoves by 2020
   b. 10 million homes adopt clean and efficient stoves by 2020
   c. 100 million homes adopt clean and efficient stoves by 2020
   d. 1 billion homes adopt clean and efficient stoves by 2020

3. ***What gender roles should be taken into account in cookstove activity planning and implementation? (name at least three)***

4. ***What is the Peace Corps' criteria for cookstove designs to promote? Check all that apply.***

   Improved cookstove options that Volunteers or other development workers promote must be:

   ☐ **Desirable** (appropriate for cooks' needs and preferences, compatible within the cultural context)

   ☐ **Accessible** (available and enabling choice, affordable outright or otherwise—e.g., micro-credit, self-help groups, etc.)

   ☐ **Effective** (actually reduce levels of indoor air pollution and fuel use); specifically related to this criteria, the Peace Corps aims to promote stoves that (a) consume 35 percent less fuel when cooking a typical meal than the traditional stove currently in use; (b) achieve at least a 90 percent reduction in emissions, as confirmed by either a standard controlled cooking test or a kitchen performance test conducted in the country

   ☐ **Reliable** (consistently performs as expected)

   ☐ **Maintainable** (easy to use and clean, spare parts and service available)

5. ***Name at least three behaviors that families can take to reduce child pneumonia mortalities (can be related to stove use or other). Check all that apply.***

- ☐ Increase use of alternatives to solid fuels for cooking.
- ☐ Properly maintain improved cookstoves, including chimneys.
- ☐ Improve kitchen and fuel management.
- ☐ Reduce child exposure to smoke: keep infants and children out of the kitchen/away from smoke during cooking periods if there is a safe supervised alternative.
- ☐ Do not allow children outside when it is cold or windy.
- ☐ Breastfeed.
- ☐ Zinc supplement.
- ☐ Immunize.
- ☐ Manage pneumonia cases well.

6. ***Match the stove types on the left to the stove characteristics (emissions and fuel source) on the right.***

Stove Types	**Stove Characteristics**		
	Answer	Particulate emissions	Fuel source
A. LPG **B.** TLUD - gasifier **C.** Rocket stove **D.** Biodigester **E.** Solar cooker **F.** Retained heat cooker		None	None. Not used for initial heating, but can be used for continued cooking once food is heated.
		Typically over 95% less than a three-stone fire	Fuel source is methane-rich gas produced when biodegradable organic material, including agricultural residue or dung.
		None	Fuel source is the sun.
		Typically 70% to 80% less than a three-stone fire	Ideal fuel source irregularly shaped wood chips with dimensions of 0.5 x 1 x 2 cm, plus or minus half of each dimension.
		Typically 98% less than a three-stone fire	Fuel source is liquefied petroleum gas.
		Typically 35% to 65% less than a three-stone fire	Ideal fuel source is cut, dry wood, but can be designed to burn coal, animal dung, or other locally available fuel source.

7. ***Name three factors influencing stove selection.***

8. Which of the following are principles of (rocket) wood-burning cookstoves? Check all that apply.

- ☐ Heat and burn the tips of the sticks as they enter the fire.
- ☐ Minimize the draft through the burning fuel.
- ☐ The opening into the fire, the size of the spaces within the stove through which hot air flows, and the chimney should all be about the same size.
- ☐ Use a grate under the fire.
- ☐ Insulate the heat flow path.
- ☐ Control the heat by the diameter of the sticks.

9. Match the standard stove test on the left to the test characteristics on the right.

Kitchen Performance Test (KPT)	This lab-based test is most appropriate for those manufacturing or adapting stove designs. It can be used to determine fuel efficiency, the time it takes to boil water, and emissions.
Controlled Cooking Test (CCT)	While this test has the most variables, it is the best test for determining the field-based results of stove use. It consists of a survey and a fuel consumption test with families using both the traditional and the improved cookstove. The test gives results of user satisfaction and per capita fuel consumption for a given stove.
Water Boiling Test (WBT)	This test involves local cooks preparing a local dish. Adding these variables limits comparability of results to a given setting but provides important feedback as to the likely acceptability of a stove by local users.