CLEAN AND EFFICIENT COOKING TECHNOLOGIES AND FUELS

5. TECHNOLOGICAL INNOVATION IN COOKSTOVES AND FUELS

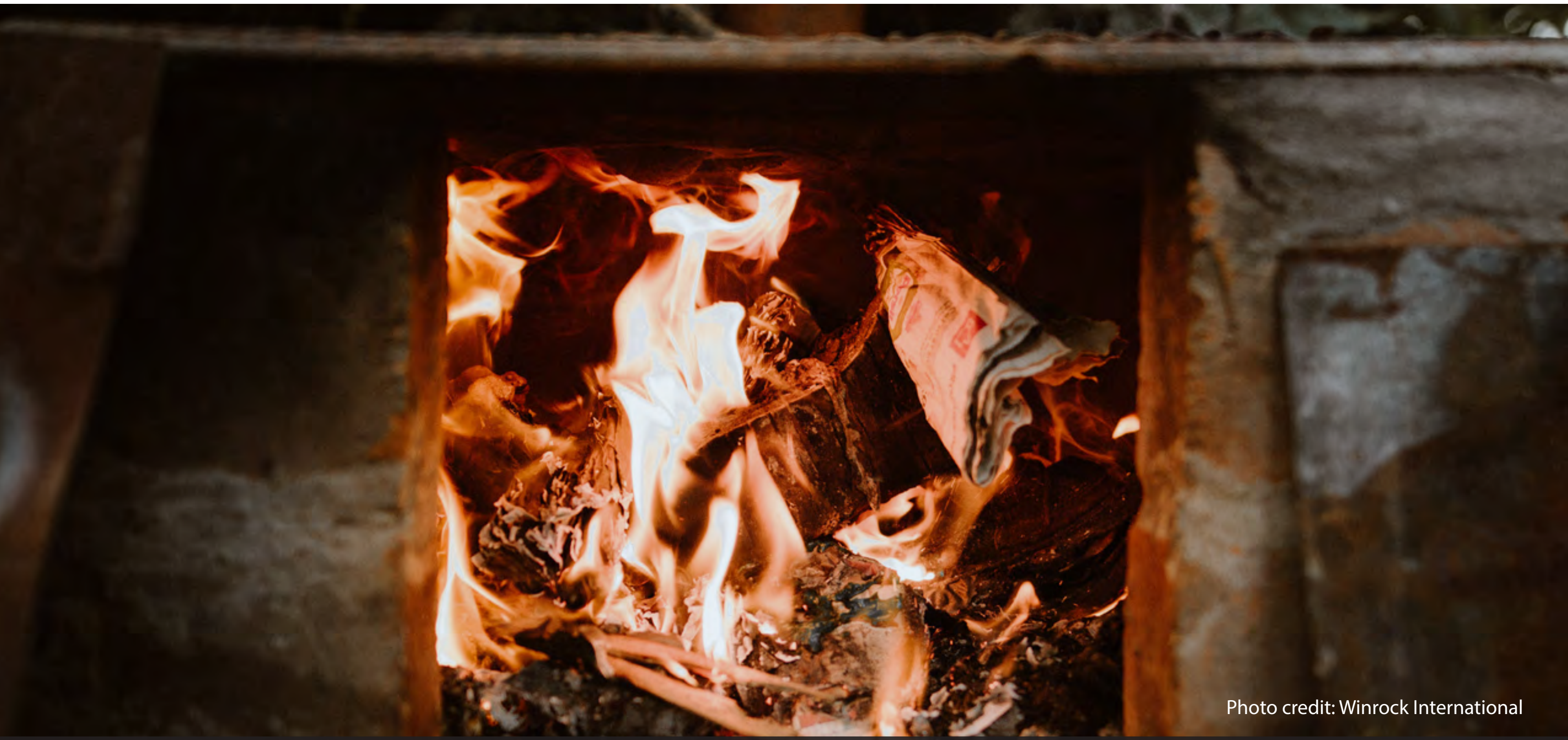

Photo credit: Winrock International

September 2017
This publication was produced for review by the United States Agency for International Development. It was prepared by Winrock International. The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

5. TECHNOLOGICAL INNOVATION IN COOKSTOVES AND FUELS

Understanding of stove design principles has changed significantly from the early days of stove projects in the 1970s and 1980s to today, as have stove and fuel production strategies and facilities. Included in this section are examples of the main technologies and fuels currently available for household, institutional and commercial use, recent advancements in research and design, as well as examples of different production strategies for stoves and fuels.

WHY IT MATTERS

Low quality or poor performing technologies or fuels not only reduce or reverse expected project impacts, but can also spoil the market for future higher quality technologies. Choosing the right stove or fuel is critical, as it must meet the primary cooking needs of the target consumer to be effective over time.

BEST PRACTICES

1. Determine which cooking technologies and fuels already exist on the market for your target consumers. Also research which technologies are made locally and which are imported, and assess the pros and cons of each.
2. Research the accessibility of different fuels where you're working. If charcoal is ubiquitous, your alternative fuel must compete not only in terms of price but also in terms of accessibility. If there's no infrastructure in place for easy (and safe) refills, liquid and gas fuels won't be adopted as primary cooking fuels and any intervention will prove unsustainable. If consumers currently collect fuel for free, project implementers must carefully research ways to introduce fuels that convince end users to invest their limited resources.
3. Stoves and fuels cannot be used interchangeably. Stoves are often – almost always – designed with a specific fuel in mind for optimum performance. Introducing a new fuel means finding the right technology to use it in! Don't assume the performance will be the same with a new fuel.
4. Keep the consumer at the forefront of the decision making process when making fuel/technology decisions. A consumer-centric approach will help you navigate the tradeoffs associated with every technology or fuel, as well as different manufacturing options.

"WE ACTUALLY HAVE SET AN ISO RECORD FOR THE HIGHEST PERCENTAGE OF DEVELOPING COUNTRIES INVOLVED IN STANDARDS DEVELOPMENT. WITH 25 PARTICIPATING COUNTRIES, 20 OF THEM ARE DEVELOPING COUNTRIES."

-ZACHARIA LUKORITO CHEPKANIA, ISO TC 285 CO-SECRETARIAT, KENYA BUREAU OF STANDARDS

RESEARCH AND TECHNOLOGICAL ADVANCEMENT IN DESIGN

Recent efforts in technological design have led to advancements in biomass cookstoves that get much closer to WHO health recommendations. Efforts to scale up access to clean burning (gas, liquid, and solar) fuels are also underway, as are innovative approaches to production and distribution of cleaner-burning biomass pellets.

AVAILABLE TECHNOLOGIES AND FUELS

The Global Alliance for Clean Cookstoves (Alliance) has been working to catalog existing cooking technologies and fuels that are available worldwide (traditional and improved), tracking key features of the technologies as well as testing results. Currently there are over 300 stoves in its Clean Cooking Catalog, which is searchable by household vs. institutional, fuel type, materials (e.g., metal, ceramic, clay), geography, and price (when pricing information is available). The Catalog allows consumers and implementers to compare technology options and make informed choices. It helps researchers and testing centers by providing initial data to inform future testing and research.

There are two main types of stoves available on the market: 1) household stoves, which are used for normal daily cooking – typically 2-3 meals per day, and 2) institutional stoves for cooking in larger group settings or for commercial cooking/restaurants. Household cookstoves, which are lower cost and more widely available, account for the vast majority of commercial sales. It is quite common for households to use more than one stove for different cooking needs. Improved institutional stoves, although not as commercially prevalent, can achieve very significant gains, especially in terms of fuel efficiency. In certain settings (e.g., schools, hospitals, refugee/IDP camps, commercial food vendors, etc.) the potential for large fuel savings can equate to large monetary savings if fuel is purchased. Where fuel is gathered (e.g., by school children or families), institutional stoves can save significant time, and – particularly in IDP/refugee settings – reduce the number of potentially hazardous trips women must take outside the camp boundaries. Fuel switching from biomass to clean fuels such as LPG may not deliver the same monetary savings, but has the potential to deliver other health or time-related benefits.

Primary cooking fuels vary by geography, but it's typical to find any combination of the following:

- Biomass Fuels: wood, dung, and agricultural waste. Note: Biomass fuels can also be processed into charcoal, briquettes (carbonized or uncarbonized) or pellets
- Liquid/gas fuels: LPG, ethanol, kerosene, biogas
- Coal (used for cooking and heating, primarily in China, India and South Africa)
- Solar/retained heat cookers
- Electricity

Photo credit: Winrock International

Different fuels have inherently different amounts of energy to release, and combust differently. For that reason, stoves are almost always designed with a specific fuel in mind. Incomplete combustion results in hazardous emissions that are released into the kitchen or environment, leading to health impacts described in more detail in the Health section. Fuel usage and combustion efficiency of biomass fuels are also impacted by how dry the fuel is (i.e., behavioral considerations for implementers), as well as how the fuel is prepared.

Nearly half the world currently cooks with biomass fuels. Even those households with access to LPG or electricity often cook some meals or foods on traditional stoves with biomass fuels. Liquid and gas fuels, when used in appropriate stoves, can be significantly faster and cleaner burning than biomass, although kerosene is not typically considered a clean fuel (it can produce high amounts of health-damaging particulates). However, access to LPG, ethanol and biogas requires the development of new distribution infrastructure and is still limited, especially in rural areas. Solar is the cleanest fuel for cooking, and free to use, but can only be used during the day when the weather is appropriate. Several groups are making advances in solar cooking technologies, but solar cookers tend to be more expensive than other options and require significant behavior change from end users. Solar is often promoted in conjunction with a second type of improved stove and a retained heat cooker, which together form an integrated cooking package.

Selecting the appropriate stove and fuel for a cooking intervention requires a thorough examination of technical options, social and market considerations, priorities, budget and implementation timeframe. The Alliance's Fuel Analysis, Comparison & Integration Tool (FACIT) and companion report can help implementers weigh various options. The online FACIT interface allows for the comparison of different environmental impacts of the production, processing, distribution and use of various cooking fuel options while also incorporating social and economic considerations. The results can be used to compare the trade-offs of different cooking fuels, identifying step in fuel production that have the largest impacts and thus presenting opportunities for improvement.

RESEARCH AND DEVELOPMENT

Recent years have brought advancements in research and development (R&D) around cleaner, more efficient cookstoves and fuels. The US Government (USG) has led several efforts in R&D for stove design and testing, primarily through the US Environmental Protection Agency (EPA) Office of Research and Development (ORD) and the US Department of Energy, Bioenergy Technologies Office. The US EPA has one of the leading cookstove testing labs at its Research Triangle Park facility. A video about its work is available on the Voice of America website. ORD expertise in cookstoves research includes stove performance, emissions, toxicology, health, climate and exposure testing. In 2014 the US EPA STAR grants program awarded $9 million in grants to better quantify health and climate benefits of cookstove changes in the context of greenhouse gasses (GHGs).

In 2014, as part of the USG support for the Alliance, the US DOE awarded $10 million in grants for research aimed at addressing technical barriers to the development of low emission, high efficiency cookstoves through activities in at least one of the following four areas: developing low cost, durable stoves that achieve stringent efficiency and emissions goals; understanding the engineering science for advanced stoves; identifying stove designs to meet local cooking needs, and; identifying the nuances of successful stove dissemination and field performance. A description of grantee activities and outcomes was presented in a webinar, accessible at: http://www.pciaonline.org/webinars/us-doe-grantee-updates.

One of the US DOE grantees, Aprovecho Research Center, produced a book available on its website detailing the design process and testing results of five biomass stoves, CAD drawings of the stoves, and guidance on how to use key design principles for heat transfer and combustion efficiency to get the cleanest burning biomass stoves possible. Another reference book for basic stove design principles is Design Principles for Wood Burning Cookstoves, which is available in English, Spanish and French at http://www.pciaonline.org/design-principles.

STOVE MANUFACTURING

Strategies and quality of manufacturing can vary greatly, but there are generally three main types of stove manufacturing, as explained by the 2014 Dalberg and World Bank report "Clean and Improved Cooking in Sub-Saharan Africa." Although this report is specific to sub-Saharan Africa, the descriptions of manufacturing types are relevant more broadly:

- Artisanal production: local artisans (micro-entrepreneurs) working with local materials on simple designs with varying, but often low, levels of quality control; usually decentralized with limited output per entrepreneur.
- Semi-industrial production: usually involves local assembly of pre-fabricated components with usually some basic tooling required for assembly; local workshops more centralized than artisanal production.
- Industrial production: centralized, larger-scale production with higher amounts of automation and tooling; higher-skilled/trained workers and higher standards of quality control.

Artisanal and semi-industrial production are more localized, with products produced in the same locale they are sold, and has often been the preferred choice of programs emphasizing local employment/income generation opportunities. Industrial production can be done at a global level (i.e., mass manufacturing in China) with finished products shipped worldwide. One significant change in recent years is the emergence of industrial production in more localized contexts. For example, BURN Manufacturing has established an industrialized production facility in Nairobi, Kenya, producing stoves for the East Africa market. Others with similar moves to local, industrialized production include international manufacturers Envirofit in Kenya and Africa Clean Energy (ACE) in Lesotho. Full industrial production is not an option for stoves that are built-in-place, which is a popular style of stove in many parts of the world, but there are ways to industrialize manufacturing of core components, ready to install in homes (e.g., ONIL stove in Guatemala, or Envirofit India).

FUELS PRODUCTION

Processed fuels, when used in appropriate, well-designed and manufactured devices, can burn cleaner and/or more efficiently than non-processed fuels. However – especially in the case of processed biomass (briquettes, pellets) - they can also produce higher levels of emissions if done poorly (e.g., used with poor quality feedstock, low levels of quality control, etc.). ***All stove and fuel combinations should be tested by a reputable, nationally or internationally recognized testing lab, before being deployed in any local context.***

Implementers that are interested in introducing a new fuel or extending an existing fuel supply chain need to be cognizant of the many behavioral, logistical and financial barriers they may encounter. New fuels often require a new stove (as it's important to match the two for best performance), and potentially a new supply/distribution chain. This requires upfront time, careful planning, additional financial and human resources, consumer education, supportive policy frameworks, and training of sales staff/promoters, among other considerations. Introducing new fuels may also disrupt existing fuel supply chains (e.g., introducing LPG, pellets or briquettes as a replacement for charcoal), which can cause problems with existing sellers or markets, and needs to be carefully approached.

Photo credit: AEST

A summary of the main categories of processed fuels are below:

a.) Briquettes. Briquettes are molds of compressed biomass, which can include agricultural waste, sawdust, coconut or other husks, and charcoal scraps/dust, or other types of waste materials (e.g., paper). They can take various shapes (depending on how compact they are) and can be carbonized or non-carbonized. Carbonized briquettes are often sold as a replacement for charcoal. It is very important to test briquettes in the stove they are intended to be used in, with a certified testing lab, before promoting them as a substitute for other fuels. In particular, non-carbonized briquettes can produce higher levels of emissions than the traditional stove/fuel combination they are meant to replace if made with poor quality feedstock and low levels of quality control. Briquette production can be done at varying levels of industrialization – from very small, local/community-based briquetting enterprises with simple machinery or manual presses to highly industrialized, centralized production facilities with more sophisticated tooling and automation. The efficiency of the production process can have a large impact on emissions as well as the amount of feedstock used. Rudimentary kilns, for instance, can use significantly more wood to create the same amount of charcoal as high-end, efficient kilns.

b.) Pellets. Like briquettes, pellets are compressed biomass, but take the form of smaller cylinders usually between 5-16mm in diameter. Pellets are often produced to be burned in gasifier stoves, which force gases and smoke back into the flame for more complete combustion. For that reason, pellets (depending on the feedstock and quality control in production) can be one of the cleanest-burning biomass fuels, when used correctly with a high-quality stove. Pellets are produced industrially in Europe (primarily for heating stoves), as well as China and India for both heating and cooking. Pelletizing technology and production in Africa and other parts of Asia are much smaller scale efforts, with Emerging Cooking Solutions in Zambia and Inyenyeri in Rwanda as two of the early pioneers in local production of pellets in Africa.

c.) Ethanol. Ethanol can be a very clean burning fuel and, unlike LPG, can be made from renewable sources. Government regulations, however, can often hinder the ability to produce and distribute ethanol at scale. For example, because ethanol is classified as an alcohol, strict regulations and fees on the import and distribution of alcohol – especially in conservative countries – can hinder scaled distribution as a cooking fuel, even if it's been treated to render it useful only for energy use; or governments may regulate its use only for transportation fuel. For decades, Project Gaia has been one of the leaders in promoting and expanding the production and use of ethanol as a cooking fuel, including through the development of micro-distilleries managed locally with modular equipment for small-scale production. More information on ethanol production, benefits and challenges can be found at: http://www.pciaonline.org/webinars/cooking-with-ethanol.

d.) LPG. LPG is one of the cleanest-burning fuels available, with high potential for health protection. However, access to LPG is still low or non-existent in many parts of the world, as poverty and poor transport infrastructure inhibit market development of the distribution infrastructure needed to create a viable supply chain. In addition, since LPG often cannot be produced domestically, it must be imported and paid for in foreign exchange, a challenge for governments and adding on to the upfront costs, especially when subsidy support within countries is not in place or fluctuates. Historically, access to LPG and electricity for cooking has increased with urbanization and rising incomes around the world, along with the appropriate enabling environment to regulate the sector and ensure public safety.

Examples of specific government efforts to increase access to LPG include Indonesia's "Kerosene-to-LPG conversion program" (2012-2014), which is reported to have reached over 50 million people. Many other governments, including those in Ghana, Kenya and India, have national campaigns to promote LPG for cooking. Global efforts to expand LPG access include the Global LPG Partnership and World LPG Association "Cooking for Life" campaign. A report created for the Alliance by WLPGA briefly examines the drivers, policies, and lessons from ten countries that have switched from traditional fuels to LPG as a cooking fuel.

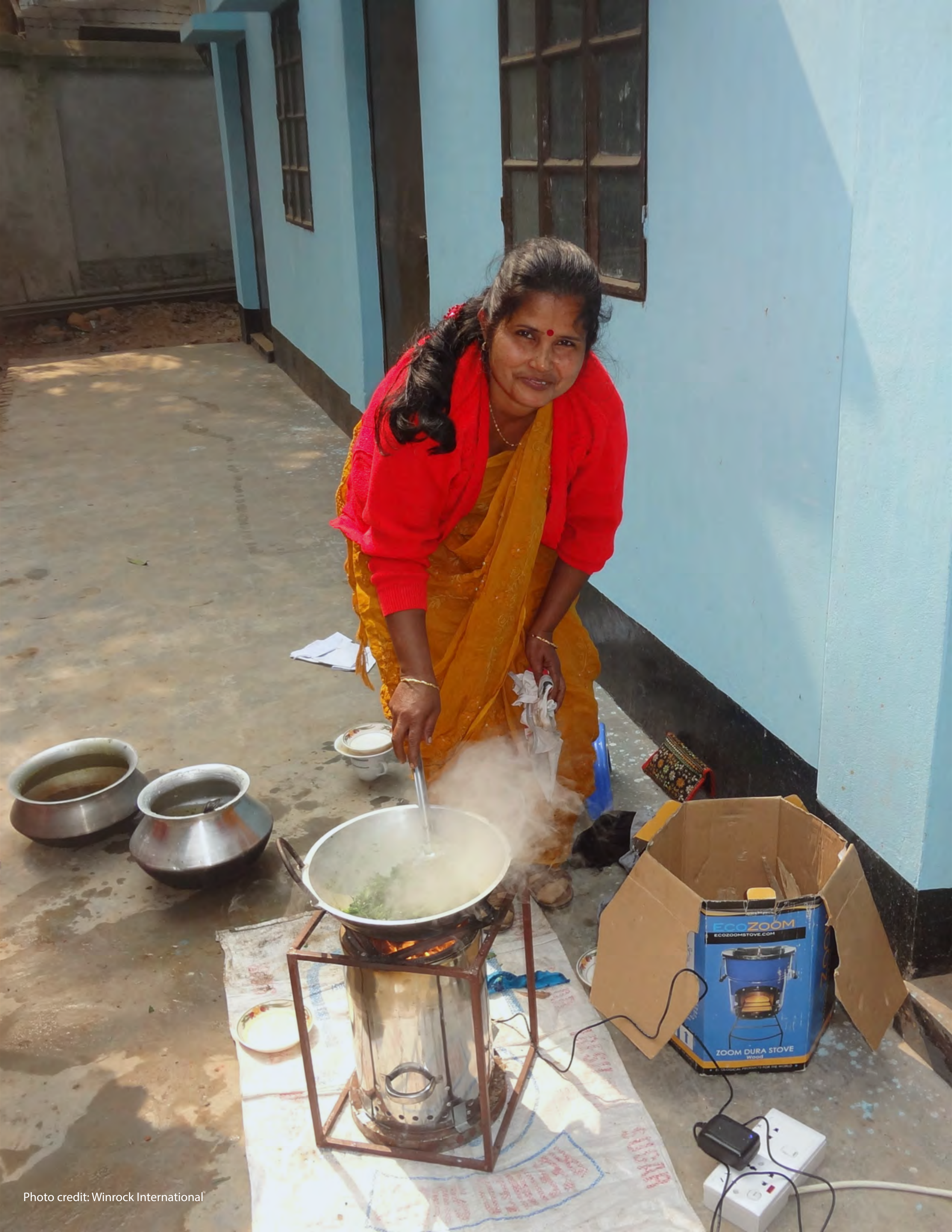

Photo credit: Winrock International