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WINROCK INTERNATIONAL

CLEAN AND EFFICIENT COOKING TECHNOLOGIES AND FUELS

THE FUEL-EFFICIENT COOKSTOVES AND CLEAN FUELS SECTOR IS EVOLVING RAPIDLY, ENABLING CROSS-CUTTING SOLUTIONS THAT CAN ACHIEVE GREATER DEVELOPMENT IMPACTS.

Photo credit: Winrock

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INTRODUCTION

WHO SHOULD USE THIS TOOLKIT?

This toolkit can be used by various stakeholders, but is primarily aimed at bringing USG staff and external project developers and implementers up-to-speed on significant developments in the cookstove sector in recent years. The goal is to showcase, through accurate and up-to-date information and links, the way cookstove projects can achieve impacts across a range of sectors, from forestry, energy and environment to livelihoods and income generation, not to mention health, school feeding, and women's empowerment. The toolkit provides an overview of how the cookstove sector is evolving, best practices, and key challenges. When designed and implemented well, cookstove programs have the potential to improve the health, livelihoods, and environment for the 3 billion people who still rely on traditional stoves and solid fuels to feed their families.

WHY FOCUS ON COOKING TECHNOLOGIES AND FUELS?

Everyone cooks. It's a fundamental, universally-shared practice that's part of every family's daily routine. However, for nearly half the world's population, the simple act of nourishing their families can also be deadly, and harmful to the local and global environment.

Cooking with traditional biomass fuels (i.e., wood, charcoal, animal dung) on rudimentary stoves or an open fire results in:

- 3 times the annual number of deaths compared to HIV/ AIDS -- more than tuberculosis, malaria and HIV/ AIDS combined;
- Consumption of 500 million tons of non-renewable wood every year;
- Greenhouse gas emissions equivalent of 170 million passenger vehicles;
- Lost productivity, time and income-generation opportunities for women;
- As much as 30-50% of household incomes being spent on the purchase of cooking fuel; and
- Safety and security concerns when people must walk long distances to gather fuel – especially in humanitarian settings where displaced populations are particularly vulnerable to assault and gender-based violence.

"I HAVE SEEN FIRSTHAND THE IMPORTANCE OF ACCESS TO ENERGY AND CLEAN COOKSTOVES, ESPECIALLY IN HUMANITARIAN SETTINGS. **THIS IS AN ISSUE THAT IMPACTS MULTIPLE SUSTAINABLE DEVELOPMENT GOALS** AND IT MUST PLAY A CENTRAL ROLE IN OUR WORK TO ENSURE THE REALIZATION OF HUMAN NEEDS AND FUNDAMENTAL RIGHTS."

ANTÓNIO GUTERRES, SECRETARY-GENERAL, UNITED NATIONS

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SECTOR EVOLUTION AND SCALE

The idea of 'improved cookstoves' (ICS) as a development issue area has been around for more than 40 years. The word "improved" tends to refer to two key areas of potential reductions – fuel use and toxic emissions - although the potential benefits extend well beyond, and can also include safety, time savings, financial benefits, and others. Early cookstove efforts primarily targeted fuel savings as a means to reduce deforestation, with a heavy focus on developing the technology, and less of a focus on meeting user needs. In these early days, stove developers didn't rely enough on technology testing, and assumed benefits that in some cases never materialized. Early stove projects typically were also isolated donor or government-led efforts, and lacked the longer-term funding, planning and coordination needed to develop sustainable local markets.

In the past 15 years, greater efforts have been made to coordinate and share knowledge amongst a growing global partnership of governments, private-sector enterprises and non-profit institutions working in the clean cooking sector. In 2002, at the World Summit on Sustainable Development, the United States government launched the Partnership for Clean Indoor Air (PCIA), led by the US Environmental Protection Agency (US EPA). PCIA was a collaborative effort to join together hundreds of global stakeholders to reduce smoke exposure from cooking and heating practices in households around the world. The launch of PCIA marked a shift from looking at the impact of cooking primarily on the environment to an equal or greater focus on how cooking impacts human health. PCIA grew from a handful of founding partners, including USAID, to a network of over 590 organizations 10 years later.

Looking for ways to increase the potential impact of PCIA through greater private-sector engagement, the US Government, including US EPA, Department of State, USAID and others worked to help transition PCIA into what is now the Global Alliance for Clean Cookstoves (the Alliance). The Alliance, launched in 2010, built off the groundwork of PCIA, integrating the existing partnership in 2012. With over 1700 registered partners by 2017, the Alliance commissions important research and assessments, provides grant funding, and plays an important advocacy role, increasing visibility of cookstove issues among governments, the global donor community, academia, and the private sector.

According to the Global Alliance for Clean Cookstoves 2016 Progress Report, partners globally reported distributing an **estimated 53 million** clean and/or efficient cookstoves and fuels between 2010 and 2015.

Photo credit: Winrock


Photo credit: Project Gaia

IMPORTANT TRENDS

While cooking technologies and/or fuels programs may allow an implementer to address multiple development issues simultaneously, cookstove projects can be successful only if sufficient resources are dedicated to addressing each issue area with thoughtful, well-informed, well-planned interventions. Experience in the sector shows that stove/fuel programs are labor intensive, especially in the early stages, and often are understaffed and/or underfunded—especially when conducted as a smaller component of a larger program. The resources in this toolkit can help project developers think through what's needed to craft high-quality projects with the most potential for impact. Sometimes trade-offs will be required in order to achieve primary objectives, but technological innovation is driving development of new and better technologies, locally-based manufacturing capabilities are improving, availability of hard data and monitoring tools is increasing, and commitment to developing sustainable, market-based interventions is growing.

Key trends that have emerged over the past 5-10 years include, but are not limited to:

- A global effort (with participation from 40 countries) towards creation of international voluntary standards for cookstoves

- A better understanding of the burden of disease attributable to household air pollution, and the emissions reductions needed to have significant impacts on health, which has become a driver of technology development for cleaner, higher-quality stoves and fuels

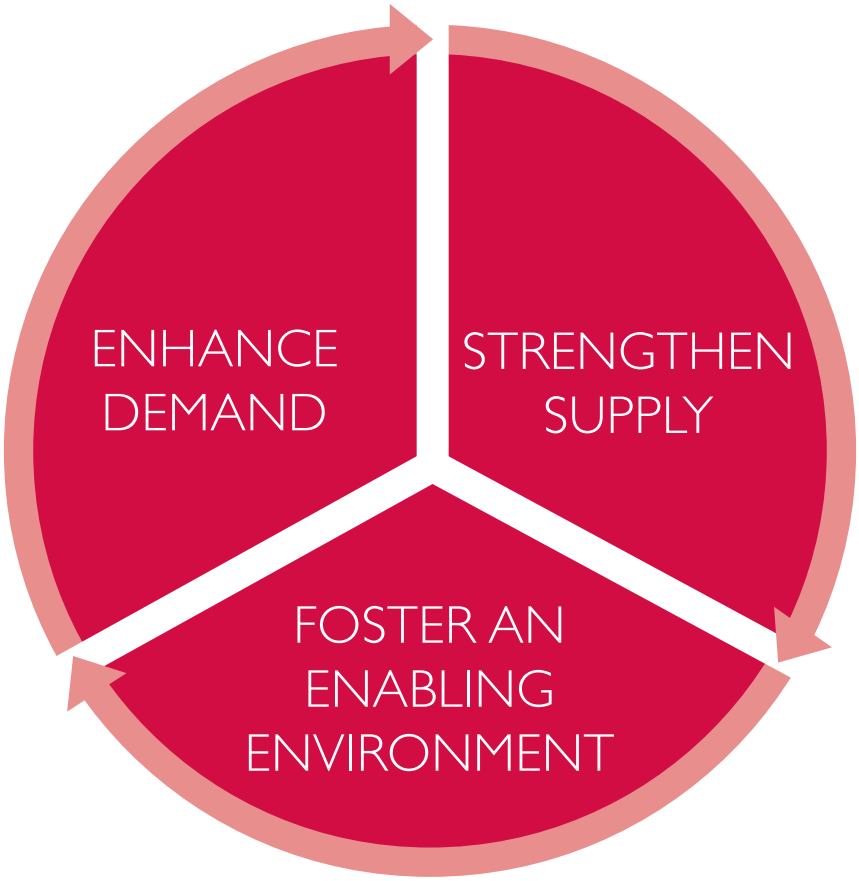
- New partnerships and platforms developed to bolster consumer and enterprise financing

- Improvements in in-country and regionally-based manufacturing capabilities, bringing quality products, at scale, closer to the end user

- The ability of stove projects to receive carbon financing; and

- Increased focus and ability to test stove performance and monitor stove usage, thereby ensuring that products meet user needs and projects attain desired outcomes.

This toolkit addresses each of these trends. For each thematic area, you'll find a highlighted section at the beginning that explains "Why it matters" and lists best practices to avoid common pitfalls. These best practices will help you design programs with the greatest potential for long term, sustainable impact.



BUILDING BLOCKS FOR DEVELOPING SUSTAINABLE PROGRAMS

What are the important considerations that need to be addressed before developing a new cooking and fuels program? These are most easily organized around three main elements of market development – supply, demand and enabling environment. All three have to be addressed adequately to achieve sustainable impacts. The sequencing of activities that will occur within each "building block" is important, and each block can impact outcomes in the others. Any cookstove program, therefore, must have a flexible design that allows the stakeholders to adapt to new data and emerging market forces. A discussion of core activities that should be planned under each building block follows. The research activities identified will help prospective program implementers to identify gaps and issues their programs must address. Because of its cross-cutting nature, monitoring and evaluation (M&E) is not listed under any specific subsection in the tables below, but critical tools for M&E can also be found in this toolkit under that section heading.

STRENGTHENING SUPPLY			
KEY ELEMENTS	**TECHNOLOGIES**	**DISTRIBUTION CHAINS**	**ENTERPRISE DEVELOPMENT**
TAKE ACTION	Find out what technologies are currently available in your target market, and if they have been tested.	Assess local distribution chains.	Determine levels and potential for private sector growth.
ASK YOURSELF...	• Is there sufficient supply to match the proposed increase in demand from project activities? • Has this technology and/or fuel been tested by a reputable testing lab? • Has this technology and/or fuel been tested with my target consumers? NOTE: If the answer to any of the above questions is "no" these must be addressed before launching any demand building activities.	• Does the physical infrastructure exist to roll out a new product or fuel? • Can my target consumer easily access this new fuel on a regular basis? • How will this new technology or fuel impact traditional stove or fuel sellers? • Is there a market/provision for replacement parts, warranty fulfillment and repair? • Are there opportunities to provide income sources for women?	• Are stove manufacturing and distribution enterprises at a nascent stage in need of significant financial and capacity building support? • What type of enterprise financing is available and how accessible is it to cookstove and fuels companies?
WHERE TO FIND INFORMATION	**Technologies and Fuels:** Includes descriptions of the main stove / fuel types and links to a catalog of available technologies. **Standards and Testing:** Provides information on testing protocols and resources available. **Health:** Includes important considerations for technology selection in health-focused programming.	**Market Development:** Describes important considerations for stove and fuels distribution. **Cross Sectoral Collaboration:** Includes best practices for integrating women into cookstove and fuels value chains.	**Market Development and Finance:** Helps you navigate strategies for strengthening supply chains and determining appropriate financing options.

ENHANCING DEMAND

KEY ELEMENTS	MARKET IDENTIFICATION	CONSUMER PREFERENCES / MARKETING	GENDER DYNAMICS
TAKE ACTION	Know your market. Identify the most likely customers/users of cooking technologies and fuels where you're working.	**Determine consumer preferences and willingness to pay** for the technologies and fuels you are proposing to promote. **Use the 4 "Ps" of the classic marketing matrix:**	Identify relevant local gender roles and norms in the area where you are working, and potential impacts.
ASK YOURSELF...	• What are the users' primary cooking needs? • How can a new fuel/technology help them meet those needs? • Can they afford to pay upfront or will they need financing? • What financing options do they have?	**Product:** • What are the current cooking habits or customs and is this technology or fuel compatible with those? • Will users need multiple devices to meet their cooking needs? • Is there significant behavior change required? • How interested is the target population in alternative fuels? • What features/ attributes do they value most? **Price:** • How much do people currently spend on cooking technologies/ fuels? • Can consumers afford the upfront or ongoing maintenance/ fuel costs? • Will they need support for these costs? **Place:** • In what region or with what consumer group is this initiative most likely to succeed? • Where should marketing or consumer awareness efforts be focused? **Promotion:** • What marketing messages or strategies have the most potential to resonate? • Cooking techniques, cultural practices and fuel sources are unique – marketing efforts need to match!	• Does the proposed activity or technology require cooks to spend more or less time tending the fire? • Could the new fuel/technology free up resources or time for cooks (primarily women) to engage in other activities? • Who is the likely purchaser vs. user and what are their different needs and priorities?
WHERE TO FIND INFORMATION	**Market Development and Finance:** Includes links to consumer segmentation studies from dozens of countries.	**Consumer Preferences and Adoption:** Provides information on strategies for getting consumer feedback on preferences and willingness to pay, which can also influence marketing strategies. **Market Development and Finance:** • Includes examples of consumer financing strategies. • Links to consumer studies that will help you choose the best location for stove / fuels promotion activities.	**Cross Sectoral - Gender:** Links to helpful resources on gender strategies and considerations for your program.

FOSTERING AN ENABLING ENVIRONMENT

KEY ELEMENTS	GOVERNMENT CAPACITY AND INVOLVEMENT	FINANCING CHANNELS (INCLUDING CLIMATE FINANCE)	GLOBAL PARTNERSHIPS	RESEARCH ON HEALTH / ENVIRONMENT
TAKE ACTION	Understand the context in which you're working. Determine what opportunities and barriers exist for scaling clean stoves and fuels.			
ASK YOURSELF...	**Government regulations** around things like import tariffs and fuel subsidies have huge impacts on potential for sustainable market success. Beyond regulation, **enforcement capacity** is also critical, especially when it comes to introducing new fuels that may have potential impact on public safety (e.g., handling and storage of LPG). **Governments can also support markets** through standards development, national level awareness campaigns, investments in critical physical infrastructure (e.g., for LPG or ethanol), and provision of incentives and/or financing.	**Available financing channels for consumers and enterprises.** Find out: to what extent are financial institutions willing to lend to cookstove and fuel companies, or to consumers? How affordable is financing from formal channels? Is mobile money available? Are there MFIs, cooperatives, table banking groups or other networks in place and willing to provide financing support? **Applicability of climate finance.** It takes significant effort and planning to develop appropriate carbon finance programs for cookstoves. There are many challenges in making these programs sustainable, but they can provide an important source of revenue.	The **Global Alliance for Clean Cookstoves** provides up-to-date information, tools and support for the clean cooking sector, and also provides in-depth sector support and awareness raising in key focus countries.	New information is continually emerging about health and environmental impacts, and several studies and trials are currently underway. The results of this research will be important to take into account in any future programming efforts.
WHERE TO FIND INFORMATION	**Market Development and Finance:** includes links to country-level market assessments that look at the macro environment. **Standards and Testing:** Includes information on international and national level standards for cookstoves and fuels.	**Market Development and Finance** Includes an overview of the types of institutions and strategies that might be available to provide critical capital to consumers or enterprises. **Climate:** Describes the types and sources of climate financing available for cookstoves and fuels, as well as challenges to consider upfront.	**Sector Evolution and Scale:** Includes more background on the Alliance and other partnership efforts. See also Cross-Sectoral Collaboration.	**Health and Climate** provide information on key research efforts, and links to sites where new research will be posted as it becomes available.

Photo credit Winrock

GROWING RESEARCH AND EVIDENCE BASE AROUND HEALTH

This section outlines recent developments in the sector's evolving understanding of the health impacts associated with exposure to smoke from cooking with solid fuels, the exposure reductions necessary to reduce health impacts, and the challenges in achieving such exposure reduction.

WHY IT MATTERS

The potential health benefits of transitioning to cleaner technologies and fuels are a major motivating factor for many improved stove programs; these are also among the most challenging benefits to achieve.

BEST PRACTICES

1. Decide what health impacts, if any, you seek to achieve. Reducing respiratory health impacts requires near exclusive use of a very high quality biomass stove or clean fuel, whereas there are many more options to reduce burns.

2. Determine what cooking technologies and/or fuels are required to achieve the desired impacts, and consider additional behavior change interventions such as increasing ventilation or removing infants from smoky areas.

3. Monitor changes in indoor emissions or exposure to household air pollution to justify any claims about specific health impacts (such as respiratory disease) and to add to the sector's limited data pool

NEW DEVELOPMENTS IN UNDERSTANDING COOKSTOVES AS A HEALTH INTERVENTION

Most cookstove programs implemented through the 1990s were driven primarily by environmental concerns; concerns about health impacts from smoke exposure and burns increased over time, and in 2002 the sector experienced a tipping point around health awareness. The 2002 World Health Organization (WHO) Global Burden of Disease (GBD) ranked indoor air pollution from household energy fourth in the list of serious threats to health in less developed countries, after malnutrition, unsafe sex, and unsafe water. The 2002 GBD estimated that exposure to indoor smoke from burning solid fuels caused an estimated 1.5 million premature deaths each year, mainly from pneumonia in children and chronic obstructive pulmonary disease (COPD) in women, from breathing in particulate matter (PM) found in smoke from solid fuels. Based on these initial GBD estimates, WHO developed the first guidelines for indoor air quality that included $PM_{2.5}$

(particulate matter less than 2.5 microns in aerodynamic diameter), and CO (carbon monoxide). Prior to this, PM and CO guidelines only existed for ambient air quality. WHO has since revised its estimates (2012), attributing 4.3 million premature deaths per year to exposure to household air pollution (HAP) from cooking with solid fuels; this revised figure includes both indoor and outdoor exposure to pollution from household solid fuels. These deaths occur primarily in South East Asia (1.69m), the Western Pacific (1.62m), and Africa (almost 600,000 deaths/year). Revised indoor air quality guidelines were also released in 2014.

The GBD findings, along with concerns about climate impacts, led to an increased international effort to better measure the emissions produced by cooking devices (the level of harmful pollutants emitted from the cooking device), indoor concentrations (level of pollutants that concentrate in the kitchen that are not vented out), and exposure levels of cooks (the amount of pollutants that the cook is exposed to during a certain time period). The main pollutants that are measured include $PM_{2.5}$, and CO, although pollutants from incomplete combustion also include nitrogen dioxide, and sulfur dioxide among others. While any particles smaller than 10 microns (PM_{10}) can pass into the lungs and cause health problems, $PM_{2.5}$ is particularly dangerous as it can pass deeper into the lungs. PM causes the most ill health and it is always present along with the other pollutants. Too much CO exposure can lead to headaches, heart conditions, and death.

UNDERSTANDING THE HEALTH IMPACTS OF HAP

Exposure to HAP has been definitively linked to acute lower respiratory infections, including pneumonia (which is the single leading cause of death in children under five years); COPD; stroke, ischemic heart disease (IHD), cataracts, and lung cancer[1], which are all counted in the global burden of disease. Additional health effects shown to be associated with household solid fuel use include babies with low birth weight, intrauterine growth retardation, perinatal mortality, tuberculosis, eye irritation, and headaches[2]. People cooking with traditional fuels and stoves also report burns and scalds, poisoning from the ingestion of kerosene, backaches from tending fires on the floor, and injuries (i.e. hernias, snake bites, backaches) and assaults incurred during fuel collection. There exists some preliminary evidence suggesting that, in addition to being disproportionately exposed to cookstove emissions, women tend to have more severe physiological responses to these exposures than do men[3].

Burns have received particular attention in recent years. WHO reports some 265,000 deaths from fire-related burns each year globally; 95% occur in low-and middle-income countries, and a large proportion of this is presumed to be cooking-related[4]. Children under 5 in the WHO African Region have almost 3 times the incidence of burn deaths vs. infants worldwide. To better understand cooking-related burn prevalence, the Alliance, CDC, and WHO have established a burns working group to increase data on the causes and risk factors of severe burn injuries. This includes a burns registry launched in India in 2013, a WHO global burns pilot that covered 46 hospitals in 26 countries and corresponding Global Burns Registry, and field based surveillance underway in Kenya and Nepal.

The Randomized Exposure Study of Pollution Indoors and Respiratory Effects (RESPIRE) study, led by Dr. Kirk Smith from 2002-2004 (with initial findings first released in 2011) was the first of its kind randomized control trial looking at the relationship between acute respiratory infections in children and exposure to indoor air pollution. This study confirmed previous findings of a non-linear exposure-response relationship for biomass particulate matter pollution and child pneumonia. RESPIRE researchers also generated similar exposure-response curves, based on other air pollution studies, for stroke, COPD, acute lower respiratory infections (ALRI) and Ischemic Heart Disease. The study found that the introduction of a chimney stove into rural Guatemalan homes traditionally using wood fuel in open fires reduced the exposure of both

1. Lim (2013), "Global Burden of Disease Study 2010."
2. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2568866/
3. http://ehp.niehs.nih.gov/0900994/
4. http://www.who.int/mediacentre/factsheets/fs365/en/


Photo credit: Project Gaia

mother and child to CO (used as a proxy for $PM_{2.5}$) by over 50% and resulted in significant reduction of 1/3 for severe pneumonia, but did not reduce physician-diagnosed pneumonia in children to a statistically significant level. The reasons for no effect being detected for non-severe pneumonia could be attributable to insufficient exposure reduction.

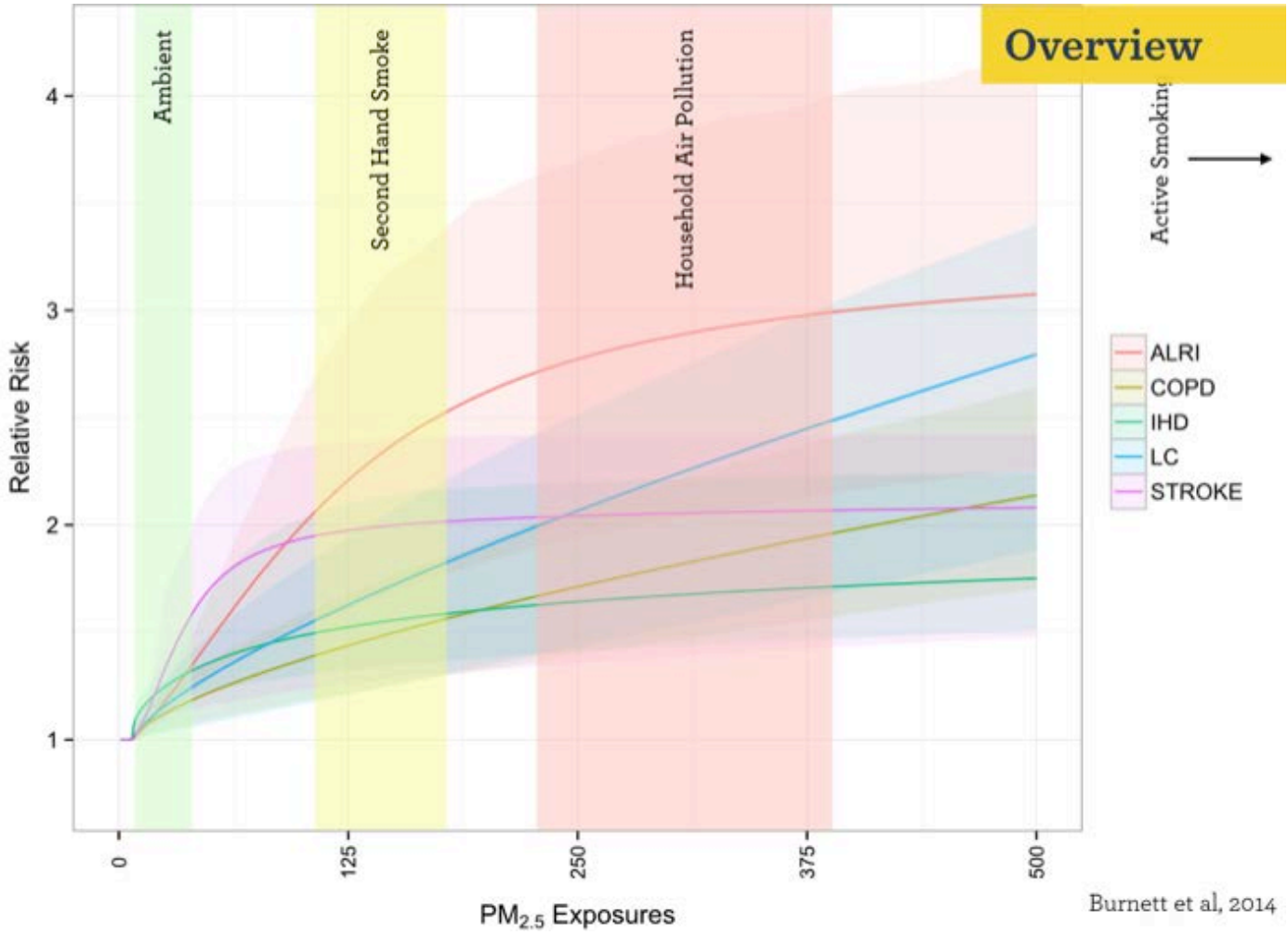
These findings show that the greatest risk reduction occurs at lower exposure levels, and that significant reductions in smoke inhalation are required for even moderate health gains for the four diseases mentioned above.

To reach protective levels--i.e. the level set by the WHO for indoor air quality guidelines--drastic emissions reductions are required. The table below[5] shows the relative risk for ALRI, COPD, IHD, lung cancer and stoke as a function of $PM_{2.5}$ exposure[6], noting typical levels for ambient pollution, second-hand smoke and HAP. A relative risk of 1 means no added risk.

Johnson and Chiang calculated that meeting the WHO Interim 1 target for $PM_{2.5}$ requires near-exclusive use of stoves that meet Tier 4 International Workshop Agreement (IWA) 11:2012 indoor emissions levels; no more than one hour per week

5. Sumi Mehta June 2016 presentation, and http://ehp.niehs.nih.gov/1307049/

6. Exposure to particulate matter less than 2.5 microns in aerodynamic diameter



of three-stone-fire burning indoors or 3 hours per week of traditional charcoal use indoors. This calculation was based on the single-zone model used for IWA 11:2012, with assumed emission sources, air exchange rate, and room volume. Additional research demonstrates the impact of increased ventilation on this model.

Other recent research efforts have included:

- Three randomized controlled trials supported by the Alliance and NIH on cooking and child survival in Ghana, Nepal, and Nigeria, all of which include a traditional stove component, an improved biomass stove component, and a clean fuels (LPG or ethanol) component.
- Four studies focused on clean cooking and non-communicable disease supported by the Alliance and the US Centers for Disease Control (through the Public Health Institute).
- Four studies focused on adoption, i.e., uptake and sustained use of demonstrably clean cooking supported by the Alliance, USAID (through the TRAction project), and the US Centers for Disease Control (through the Public Health Institute).
- An Alliance, WHO, and US Centers for Disease Control (US CDC) joint effort to develop an international burns registry to estimate the proportion of severe burns that is due to cooking.
- The National Institutes of Health have also been active in researching health impacts of cookstove interventions.

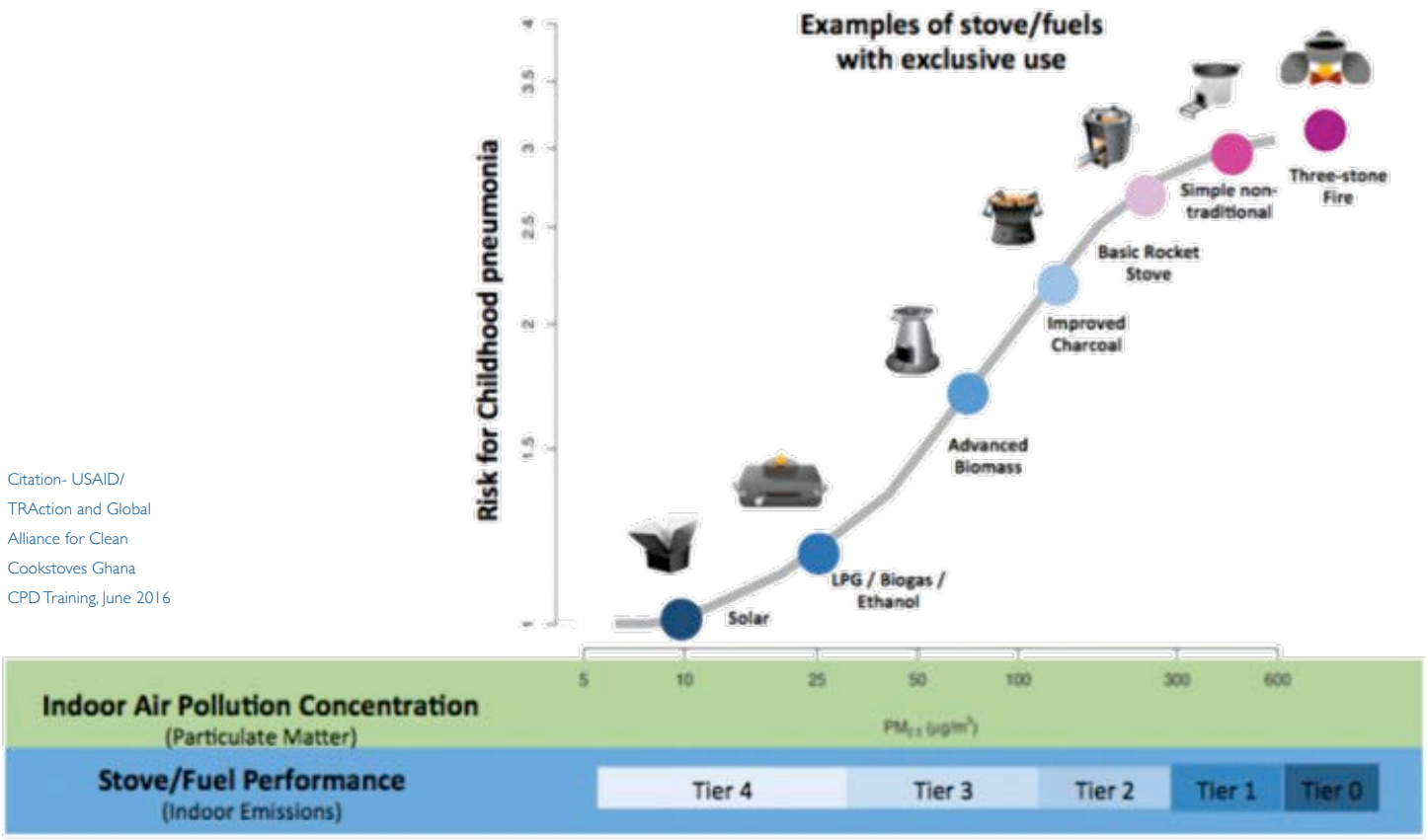
As the health effects of improved cookstove interventions are better understood, means for assessing these impacts have

evolved. The WHO Catalog of Methods details many of these methods. The principal way by which the health impact of a specific intervention can be assessed is averted disability-adjusted life years (aDALYs): a composite metric used by health and development entities globally to measure disease burden or risk factors to evaluate interventions. The Household Air Pollution Intervention Tool (HAPIT) is a recently-developed web-based tool that allows users to estimate the impact of particular cooking system interventions on the burden of disease by generating aDALY estimates. The tool requires stakeholders to input parameters from the intervention program, including data on targeted households, intervention lifetime, and intervention cost, as well as field data, such as exposures to $PM_{2.5}$ and stove usage data, to calculate the health impacts of the intervention in aDALYs, and relative cost effectiveness. WHO is also developing a Clean Household Energy Solutions Toolkit (CHEST) with tools, guidance and other resources to be used at the local, national or regional level to support implementation of their indoor air quality guidelines. This will include guidance for needs assessments and mapping, assessments of intervention options, M&E strategies and resources, policy options and standards and testing information.

BARRIERS TO ACHIEVING HEALTH IMPACTS THROUGH COOKSTOVE INTERVENTIONS

The primary challenge in achieving respiratory health impacts through cookstove interventions lies in the fact that, to achieve WHO guideline levels of exposure, users not only must use extremely clean (Tier 4 for indoor emissions) stoves and fuels, but also must use them almost exclusively. WHO's CHEST tool, referenced above, will help support implementers to incorporate this guidance in their programs, but there are still real challenges to getting this level of health impact currently.

Though Tier 4 (indoor emission) biomass stoves exist, few (if any) are commercially available in most countries (see



Citation- USAID/ TRAction and Global Alliance for Clean Cookstoves Ghana CPD Training, June 2016

results from a current round of U.S.EPA testing shown by category below). Stove categories are plotted against relative risk for childhood pneumonia). Even when Tier 4 (indoor emissions) stoves are available, stove stacking with traditional stoves, at levels far greater than 1 hour/week, is commonplace. As such, it is difficult for most current biomass cookstove interventions to provide significant respiratory health benefits. LPG and ethanol stoves/fuels are cleaner burning than biomass, and have greater potential for respiratory health protection, but stove stacking with LPG/ethanol and traditional stoves still exists, and access to LPG and ethanol (including infrastructure, distribution chains, and affordability) is still low or non-existent in many parts of the world. Global efforts to expand LPG access include the Global LPG Partnership and World LPG Association "Cooking for Life" campaign.

While health interventions aimed at respiratory health improvements require almost exclusive use of extremely clean technologies, important non-respiratory health improvements are achievable through currently available biomass stove models. These include reducing burns and scalds, kerosene poisoning, eye irritation, headaches, backaches, hernias, and other physical impacts of fuel collection. Of note, these impacts result in significantly fewer deaths and DALYs than respiratory diseases do.[7]

While there are currently no agreed-upon USAID indicators for HAP yet, emerging results from ongoing studies such as the child survival studies funded by the NIH and the Alliance (publications in progress) are promising, and will further inform the question of how 'clean' is clean enough to provide health benefits such that USG and other donors/implementers can measure progress toward health goals. The HAPIT tool described above is consistent with the latest burden of disease estimates, and calculates and compares the health benefits attributed to proposed stove and/or fuel intervention programs. This tool will continue to be updated as the existing evidence base continues to evolve.

ADDITIONAL RESOURCES:

Global Burden of Disease Methodology
http://www.healthdata.org/gbd/about
http://www.annualreviews.org/doi/abs/10.1146/annurev-publhealth-032013-182356
http://ehp.niehs.nih.gov/1307049/
http://www.who.int/publications/cra/chapters/volume2/1435-1494.pdf
http://cleancookstoves.org/resources_files/briefing-note-on-burden-of-disease.pdf

2010 Estimates – IHME (includes national burden estimates)
http://www.thelancet.com/journals/lancet/article/PIIS0140-6736(12)62135-7/abstract
http://www.healthmetricsandevaluation.org/gbd/visualizations/country

WHO 2012 Estimates (only deaths, only air pollution)
http://www.who.int/phe/health_topics/outdoorair/databases/en/

2013 Estimates – IHME
http://www.healthmetricsandevaluation.org/gbd/visualizations/country

Household Air Pollution Intervention Tool (HAPIT)

www.cleancookstoves.org/HAPIT

7. Lim SS, Vos T, Flaxman AD, et al. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2012;380(9859):2224-2260. doi:10.1016/S0140-6736(12)61766-8.

CLIMATE IMPACTS OF TRADITIONAL STOVES AND FUELS

Burning solid fuels for cooking emits some of the most significant contributors to global climate change, and unsustainable wood harvesting contributes to deforestation, reducing carbon uptake by forests. Increased fuel efficiency and the introduction of alternative fuels, utilizing renewable fuel sources, can reduce climate emissions caused by cooking. To achieve a significant climate impact, uptake of clean and efficient stoves and fuels must be large, and stoves must perform well in homes. Although not all climate impacts of cooking are fully understood, existing methodologies estimate that clean and efficient stoves can save anywhere from 1-3 tonnes of CO_2e/stove/year, with 1-2 tonnes being most common.

Photo credit: Winrock

WHY IT MATTERS	Burning solid fuels for cooking emits some of the most significant contributors to global climate change, but the climate impacts of cooking, and of shifts to clean cooking, still require further research and exploration.
BEST PRACTICES	**1.** If your project has climate impact goals, make sure the technology you're promoting has been tested for total emissions, or partner with a reputable testing lab to test the technologies, including in the field, prior to dissemination, to ensure emissions reductions. **2.** Investigate carbon finance opportunities, but ensure that carbon revenues are not essential to the project's overall sustainability. Carbon prices can fluctuate dramatically, and carbon markets require significant upfront resources and time to navigate, which must be considered and planned for during project design.

CARBON FINANCE / CALCULATING CLIMATE IMPACTS

According to Bailis et al, over half of all wood harvested worldwide is used as fuel, and biomass used for cooking is 27-34% non-renewable (unsustainably harvested), with large variations by country/region. Burning solid fuels releases carbon dioxide, methane and other ozone producing gases such as carbon monoxide, as well as short-lived climate forcers like black carbon. Up to 25% of global black carbon emissions are estimated to come from burning solid fuels for household energy needs. According to a 2013 report by the Stockholm Environment Institute, the global potential for greenhouse gas (GHG) emission reductions from improved cookstove projects is estimated at 1 gigaton of carbon dioxide equivalent (CO_2e) per year. Carbon markets can incentivize reducing these emissions.

Carbon finance refers to the purchase of greenhouse gas (GHG) emission reduction credits from a registered project that has been approved to generate those carbon credits by any number of governing bodies that govern the carbon markets. To claim carbon credits, a project must first be registered to an international carbon standard in the compliance or voluntary market. The primary compliance mechanism is the Clean Development Mechanism (CDM), and the Gold Standard is the primary voluntary carbon standard. These carbon standards have sets of rules that determine what a project must do to become registered, how credits will be calculated, and what monitoring is required to verify emissions reductions. While the whole system is based on getting results at scale, there are mechanisms for smaller-scale projects to receive carbon finance through joining a small-scale Program of Activities (PoA), which is an aggregation of smaller projects. Also worth noting is that, while there have been linkages made between cookstoves and REDD+ goals, to date efforts to promote cookstoves as part of REDD+ financing mechanisms have been limited.

Carbon finance developers can help navigate the process of setting up a carbon program for a fee, as it can be complicated for those new to the system. As of 2016, carbon prices are very low, and the primary option for carbon revenues is to sell credits to a select few national governments who are occasionally willing to sign forward contracts, (wherein the price of carbon is set in advance for the duration of the project). Forward contracts are scarce but possible from EU country governments through CDM, or through the World Bank's Carbon Initiative for Development (CI-DEV) fund. Some companies are also willing to pay higher prices through forward contracts as part of corporate social

responsibility initiatives. Under any of these scenarios, credit payments are received only after the project is in full implementation (e.g., after stoves are already being used in homes), which can limit the involvement of organizations that need upfront financing to get programs started, or to pay for the M&E requirements and verification costs that are needed to start and continue receiving payments.

At the Paris climate conference (COP21) in December 2015, 195 countries adopted the first-ever universal, legally binding global climate deal, which is due to enter into force in 2020. While a carbon trading system including carbon offsets is expected to be part of the new system, what form such a market will take is unknown.

Various models exist to calculate carbon impacts. A Global Alliance-supported research project entitled "Geospatial Analysis and Modeling of Non-Renewable Biomass: WISDOM and beyond" developed two models to simulate the impacts of woodfuel consumption on forest resources at different scales. The first relies on a web-based map server that shows the results of a pantropical woodfuel sustainability analysis. Users can download estimates of overall woodfuel consumption and non-renewable wood harvesting for any geographic unit of interest. These data can be used to calculate CO_2 emissions resulting from woodfuel consumption and estimate the potential benefits of wood energy interventions in different regions. The second, NRBv1.0, is a software tool that assesses woodfuel-driven forest degradation or deforestation for smaller geographic regions. The tool uses several freely available software packages to simulate wood extraction and woody biomass regeneration within a user-defined geographic region. The objectives of simulations are 1) to demonstrate where and when woodfuel demand is likely to contribute to forest degradation and 2) model the impact of interventions that aim to reduce woodfuel consumption.

USAID and Winrock developed the AFOLU carbon calculator as part of the USAID Carbon Reporting Initiative. The calculator uses the Intergovernmental Panel on Climate Change (IPCC) accounting methods to estimate the potential climate benefits of different types of projects, including clean cooking interventions.

BLACK CARBON

Black carbon is a small, dark particle that is released as a result of incomplete combustion of solid fuels. Although black carbon is a particle rather than a greenhouse gas, it is the second largest climate warmer, after carbon dioxide. A 2013 study by black carbon expert Tami Bond and 30 other experts published in the Journal of Geophysical Research-Atmospheres says the current influence of black carbon on warming the climate may be about two-thirds of the effect of carbon dioxide. Unlike carbon dioxide, the atmospheric lifetime of black carbon is only a few days, so reducing black carbon would bring about a more rapid climate response than reductions in carbon dioxide and other long-lived greenhouse gases alone. While black carbon definitely has climate warming effects, other aerosols that are lighter in color are also emitted from the burning of biomass and fossil fuels, and these produce a cooling effect. Further complicating the issue, the impact of black carbon reductions on climate depends on geographical characteristics. For example, the warming potential of black carbon abated in the Himalayas (due to white surfaces) is much greater than in central Africa.

According to Dr. Veerabhadran Ramanathan, professor of climate sciences at the Scripps Institution of Oceanography at UC San Diego and leading expert on the role of black carbon in regional and global climate change, it is probable that greenhouse gas emissions to date will cause warming of close to 2 degrees Celsius, but that with available technologies, it is possible to cut short-lived climate pollutants drastically. He and colleagues note that reductions of 30% for methane, 75% for black carbon, and nearly 100% for the most potent hydrofluorocarbons are achievable. This would avoid up to 0.6 °C of warming by mid-century, while also slowing the rise in sea levels, the melting of glaciers, and the retreat of the Arctic ice cap[1]. Dr. Ramanathan leads Project Surya, the only project currently monetizing black carbon. Project Surya aims to mitigate the regional impacts of global warming by reducing atmospheric concentrations of black carbon, methane, and ozone,

1. http://www-ramanathan.ucsd.edu/files/pr212.pdf


Photo credit: Project Gaia

through the introduction of cleaner cooking technologies, and is currently working in India.

In 2015 The Gold Standard launched a methodology for quantifying and monitoring emissions from black carbon and other short-lived climate pollutants, in an effort to drive finance into projects that provide an immediate and measurable impact on mitigating climate change at a local level. This methodology quantifies the emissions of black carbon and other short-lived climate pollutants when wood, charcoal, animal dung or coal are burned for cooking. It also measures the reductions of these emissions when improved cookstove technologies or clean burning fuels are introduced. Rather than carbon credits, this methodology results in the issuance of black carbon certificates. There have been no transactions to date using this methodology, perhaps because of the absence of a measure like CO_2e that is widely understood and easy to monetize. Developing such a measure, or link to CO_2e, could benefit the monetization of the climate co-benefits.

Many of today's more efficient cookstoves have been shown to reduce fuel use by 30-60%, and provide cleaner, more complete combustion, which can result in fewer greenhouse gas and black carbon emissions and reduce impacts on forests. Recent evidence also demonstrates that advanced (efficient and low emission) cookstoves and fuels can reduce black carbon emissions by 50-90%. Emission reductions are not guaranteed to accompany fuel reductions, however, so it's important to measure emissions in addition to fuel use. The Gold Standard black carbon methodology includes a number of approved black carbon monitoring devices and approaches.

"YOU DON'T GET WHAT YOU EXPECT,
YOU GET WHAT YOU INSPECT."

DR. KIRK SMITH, JUNE 2007, ENERGY FOR SUSTAINABLE DEVELOPMENT.

Photo credit: Berkeley Air Monitoring Group

INTERNATIONAL STANDARDS AND TESTING PROTOCOLS

Performance testing and standards development for cooking technologies and fuels help implementers, investors, donors, and consumers alike differentiate between varying levels of product performance, safety, and quality. Standards and testing also help manufacturers identify ways to make improvements to product performance, thereby distinguishing their products in the market and ultimately achieving greater impacts.

WHY IT MATTERS

Untested "improved" stoves can have higher emissions and/or lower efficiency than the traditional options they are meant to replace, and promoting inadequate technologies can reduce or reverse expected project impacts, and also spoil the market for future higher quality technologies. The use of cookstove standards and testing can help ensure programs are able to meet their impact goals.

BEST PRACTICES

1. Find out what test results already exist for cooking technologies and fuels on the market for your target consumers – the Alliance's Clean Cooking Catalog is a great starting point. It includes test results for various technologies searchable by country.
2. Compare these results with international cookstove standards to ensure your choices meet performance criteria established by the funding agency or local government.
3. Undertake in-country testing of the cookstoves you plan to promote, to ensure that they perform well with local foods and fuels.

STOVE TESTING

To better ensure and understand program benefits, donors and implementers need to use testing data for candidate stoves and fuels before undertaking any large scale dissemination efforts.

TESTING PROTOCOLS

Cookstove performance, and especially the achievement of fuel and emissions reductions, can only be verified through testing. Standardized laboratory testing protocols and metrics allow for replicability and comparability among tests and across stoves. As stoves often perform differently when consumers use them in their own homes, field testing in consumer homes often provides a more realistic picture of actual stove performance. Field testing allows for more relevance between the test results and potential impacts, but with less comparability among tests and stoves. Laboratory testing often represents the best possible performance under ideal conditions, but cookstoves that perform well in the

lab (where the standard test is boiling water) may not always perform well cooking a specific local food, or with non-standard fuels.

Three common standardized tests are the Water Boiling Test (WBT), the Controlled Cooking Test (CCT), and the Kitchen Performance Test (KPT). The laboratory-based WBT is the most standardized of the three, and allows for comparison between stoves. The CCT assesses the performance of stoves relative to the traditional baseline, and consists of multiple cooks cooking a typical local meal (using the same amounts of the same ingredients) multiple times for each stove tested. The KPT measures the impact of the introduction of the stove on household fuel use. This is a function not just of stove performance, but also the degree to which consumers replace their traditional cooking option with the improved stove. More detail on these and other testing protocols are available here: http://cleancookstoves.org/technology-and-fuels/testing/protocols.html.

Testing protocols are consistently updated and reviewed by the global community to ensure methods for lab and field testing provide the best possible depiction of how each stove performs. For example, testing protocols are being evaluated and updated through an ongoing international standards process (see below). The Global Alliance for Clean Cookstoves' Clean Cooking Catalog includes test results for many cooking technologies and fuels available worldwide.

Photo credit: Winrock

REGIONAL TESTING AND KNOWLEDGE CENTERS

An effort to expand global capacity for, and increase access to, quality testing services has been underway for several years, resulting in several Regional Testing and Knowledge Centers (RTKCs) established around the globe. RTKCs provide independent cookstove and fuel testing services (both lab and field testing) to local manufacturers, implementers donors, investors, and governments, and are often able to provide recommendations for improving cookstove design based on these test results. Many offer related trainings and knowledge resources for local stakeholders. For a full list of RTKCs available to consumers and manufacturers, please see: http://cleancookstoves.org/technology-and-fuels/testing/centers.html.

INTERNATIONAL COOKSTOVE STANDARDS: A BRIEF HISTORY

The goal of current efforts to develop international voluntary performance standards is to increase the ability of consumers and policy makers to differentiate between cooking options and increase incentives for manufacturers to develop the cleanest and/or most efficient technologies and improve these over time.

International performance standards for cookstoves have been under discussion in the clean cooking sector for over a decade. Standards benefit:

- Consumers by providing confidence in product quality
- Donors and investors by ensuring funds are invested in products with the highest potential for impact
- Manufacturers by driving innovation and ensuring fair competition of products on the market
- Governments by providing an international framework with which to develop their own national standards and product labeling and facilitate collaboration and trade.

The first significant advancement toward the development of international cookstove standards came in 2011 through the Lima Consensus, which established an interim rating system for the evaluation of cookstove models "that reflects the varying tiers of performance in the areas of fuel efficiency, indoor air quality, emissions of particulate matter and carbon monoxide, and safety."

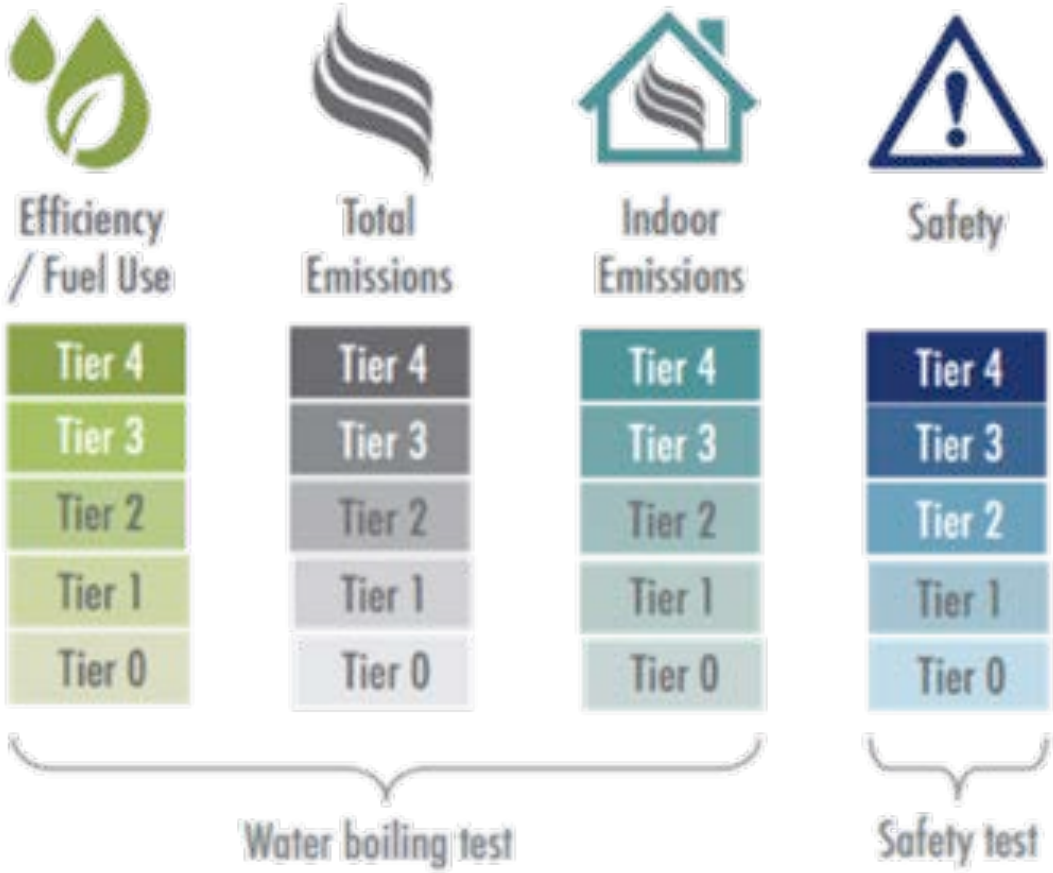
The basic principles laid out in the Lima Consensus were later used as the basis for the International Standards Organization (ISO) International Workshop Agreement (IWA) on Cookstoves, which was finalized and unanimously affirmed by more than 90 stakeholders at the ISO International Workshop on Cookstoves in 2012 in the Netherlands. Rather than select a single laboratory protocol to determine cookstove performance, the IWA sought to enable stove testers to utilize multiple options from a set of internationally-recognized laboratory protocols most appropriate for the stove and performance indicator being tested. That said, the tiers developed were based on the Water Boiling Test, as the sector has the most data available for that test, with the future goal being to develop tiers for other testing protocols.

The affirmation and widespread use of the IWA led to the establishment of ISO Technical Committee 285, which brings experts in the clean cooking sector from all over the world together to develop international voluntary standards for technologies and fuels meant to replace traditional cooking with solid fuels. These international standards can be used as guidance by countries seeking to set their own national standards (some examples include Bangladesh, Ghana, Guatemala, Kenya, Mexico, Nepal, Nigeria, Uganda and others). For countries that already have standards in place, (e.g. Bolivia, China, India and others) the international standards can facilitate international collaboration and trade. The standards and the interim IWA tiers can also be used to prescribe cooking options eligible for support or inclusion in donor-supported programs

TIERS OF PERFORMANCE

The IWA established tiers of performance to rank stove performance across each of the 4 criteria (efficiency, total emissions, indoor emissions and safety), across a ranking spectrum from 0, which represents the performance of typical baseline open/three-stone fire, and 4, which represents a longer-term aspirational goal for biomass stoves. For total emissions (all emissions emitted by the stove, including those vented out of the kitchen) and indoor emissions (only those emissions emitted indoors, not including any vented by a chimney), the Tier 4 level is pegged to achievement of WHO interim indoor air quality guidelines. Many liquid and gas stove/fuels (ethanol and LPG, but not kerosene) meet Tier 4 emission levels, as can some biomass stoves that have fans or burn processed biomass. Stoves are ranked from 0-4 for each tier level separately, so a stove will end up with scores that look like 3/3/2/4. These scores are not combined and there is no single overall ranking.

USAID and other donors should consider first the primary impacts they're trying to achieve, and then relate those impacts to the tiers that are most appropriate. For example, for programs most interested in fuel savings, the efficiency/fuel use tier levels will be the most important. For a health-related program, the indoor emissions tiers likely would become the primary determinant for a cookstove's inclusion in a program. For a climate-focused program, total emissions and efficiency/fuel use might be the most appropriate determinants. Donors should keep in mind that "Tier 4" was set as 'aspirational', especially for emissions – it is achievable to varying degrees depending on the tier category and type of fuel, but asking implementers to promote only Tier 4 stoves across the board is not yet realistic (if the ultimate objective is to maximize dissemination). It's important to prioritize which categories of performance are most important to the work you're trying to achieve, then set more stringent criteria as technologies improve and distribution channels are developed.



THE WAY FORWARD

At an initial meeting in Nairobi, Kenya in 2014, ISO Technical Committee 285 formed four working groups responsible for developing draft standards and guidance documents on:

1) A framework for stove and fuel evaluation
2) Harmonized protocols for lab-based testing
3) Guidelines for field testing, and
4) Guidelines for examining social impacts

Working drafts for most working groups are expected to be completed by late 2017. They will then be reviewed by TC 285 participating countries (through their national committees) and finalized by the working groups, at which point all ISO member countries will have the opportunity to vote to approve the standards. National-level committees will determine how best to implement the standards within their specific settings in a way that is harmonized within their region and internationally.

Photo credit: Winrock

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

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.

ADVANCES IN QUALITY MANUFACTURING

The presence of quality, local production facilities are becoming increasingly central to scaling up adoption of advanced biomass stoves, as well as other technologies and fuels.

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

CONSUMER PREFERENCES AND STOVE ADOPTION

This section provides background information and guidance on cookstove adoption, the importance of consumer preference and how to assess it, the confounding effect of stove stacking (using multiple technologies or fuels in parallel), and how and why to monitor stove use.

WHY IT MATTERS

Cleaner, more efficient cookstoves have the potential to generate a variety of social, economic and environmental benefits, but these benefits can be achieved only if consumers use these stoves correctly and predominantly. The stove's ability to meet consumer needs and expectations is critical both to ensure use, and to build market demand.

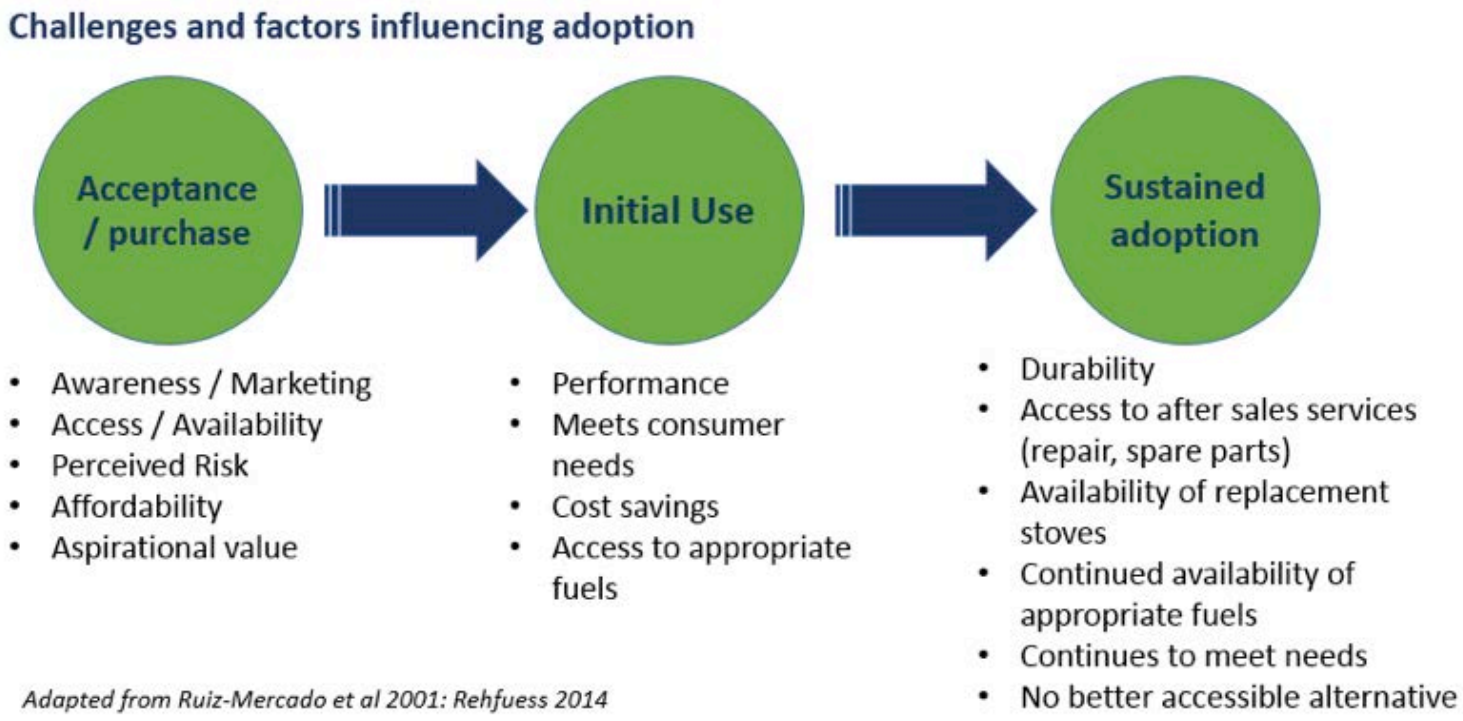
BEST PRACTICES

1. Gather consumer research data from existing studies and through household trials, if necessary, to determine whether available stove options are a good match for your target consumers. If not, solicit consumer input to help design or modify a stove with attributes that better meet the needs of your target market.
2. Build consumer education into your program, through product and social marketing, to ensure that end users understand how to use the new fuel/technology and do not hold unrealistic expectations.
3. Monitor stove usage of a representative sample of users via sensors to collect unbiased data on whether they are actually using the stoves, and to what degree; follow-up with consumers to learn more and resolve issues that limit the consistent use of improved stoves.
4. Ensure the supply chain can provide after-sales service. Troubleshooting support, repair shops, warranty fulfillment and availability of replacement parts are critical to reduce risk for the consumer, build brand loyalty, and ensure that consumers continue to use cleaner cookstoves and don't revert to traditional stoves/fuels.

STOVE ADOPTION

Stove adoption consists of three key stages: 1) uptake/purchase; 2) initial use; and 3) sustained, consistent use (which also includes repair and replacement). Adoption is sometimes equated only with acceptance and initial use, but sustained

adoption (e.g., long-term, consistent use) is critical to achieving greater impact. The factors that influence each stage of adoption vary, but center around ease of access; perceived risk; affordability and financial constraints; stove performance; and consumer expectations, **as summarized in the chart below:**



A systematic review of the existing literature on "Key factors influencing adoption" was completed by Puzzolo et. al in 2013. The review found that "factors such as meeting household needs, fuel savings, higher income levels, effective financing and facilitative government action" were all deemed "necessary but not sufficient" on their own to guarantee adoption, and are highly dependent on context. Two USAID projects, the environmental health project WASHplus and the research project Translating Research into Action (TRAction) have devoted considerable effort to trying to understand the factors that influence sustained adoption of ICS. In an article summarizing the findings of a meeting of the Working Group to Address Increasing Adoption of Improved Cookstoves hosted by the two projects, the authors noted that "The adoption of clean cooking technologies goes beyond mere product acquisition and requires attention to issues of cooking traditions, user engagement, gender dynamics, culture, and religion to effect correct and consistent use."

UNDERSTANDING CONSUMER PREFERENCE AND BEHAVIOR

Consumers will only purchase, use, and especially exclusively use, cookstoves that meet their cooking needs and priorities. These priorities include how consumers value performance and convenience/usability tradeoffs. For example, while cooks generally appreciate fuel savings, fuel savings that are achieved at additional burden of having to chop fuel wood into small pieces and continuously feed the fire may not be an acceptable tradeoff, compared to a low-maintenance traditional stove. Consumer research can help identify stove designs and features that are most valued by a particular consumer group for their main cooking needs, making it more likely that cooks will use the stoves consistently. Through human-centered design approaches, wherein consumers are engaged at the product design level through focus groups, individual interviews, household trials, or market demonstration events, they can provide their input into the development of new stove models.

Photo credit: Clioma

More details on these kinds of tools for engaging consumers can be found in the Global Alliance for Clean Cookstoves (Alliance) guide on Market Research in the Clean Cooking Sector, developed in collaboration with WASHplus. Findings from consumer focused studies commissioned by the Alliance and its partners can also be found on the Alliance website. For those considering interventions in South Asia, the Cooking Energy Service Decision Support Tool, prepared by the Ashden India Renewable Energy Collective, was developed to help stakeholders "ensure that endusers are at the centre of the decision making process for product selection."

Consumer research can also identify consumer education needs; i.e., messaging that guides consumers on how to use the stoves to best achieve their own priority benefits, especially when stove operation differs from their traditional experiences. For example, consumers used to an open fire with leaping flames might need education to understand—and accept-- that the stove can still cook their food quickly and will use fuel more efficiently with enclosed combustion. Likewise, consumer research can help inform strategies for guiding consumers through new practices that have tangible consumer benefits, and are equally important to sustained adoption, such as warranty registration or ongoing care and maintenance.

Understanding consumer preference is equally important for building market demand and identifying target consumers, as well as informing marketing and financing approaches. It is important to understand that an enduser's priorities may not be the same as a donor's; in some cases, social status or aspirational goals might be as important (or even more important) than more tangible benefits such as smoke reduction or cost savings. USAID|TRAction sponsored a special issue of the Journal of Health Communication on "Advancing Communication and Behavior Change Strategies for Cleaner Cooking" on the role of behavior change strategies within the clean cooking sector and can provide insights for stakeholders crafting marketing and communications strategies around clean cooking.

Identification of different customer segments is important as it allows an organization to structure its marketing strategy around the wants and needs of those particular segments, instead of trying to reach everyone with a "one size fits all" approach. This can be especially relevant if a manufacturer or program implementer is working in multiple settings (i.e., rural and urban) and with households at various income levels, as each type of consumer may respond to a product or marketing message in very different ways. Knowing the types of features and benefits that target consumers value most helps manufacturers and distributors craft marketing messages that are more likely to resonate with the intended purchaser and user. For instance, a WASHplus consumer preference study in Bangladesh found that none of the improved stove models studied were sufficiently appealing to consumers to include in a national stove program, whereas a similar study in Nepal found enthusiastic interest in very similar models. Both studies, which used a technique called Trials of Improved Practice (TIPS) (see below), helped inform financing options that were made available to consumers in Nepal through an ongoing government-coordinated campaign.

Trials of Improved Practice (TIPs) is one type of consumer research that can be especially useful in assessing consumer preferences and behavior. TIPs consists of in-home trials of the improved technologies, combined with quantitative and qualitative information gathering through semi-structured questionnaires. The WASHplus project has published a TIPs-focused consumer research toolkit available here: http://designlab360.org/washpluscookstovetoolkit/. Households may be asked to compare cooking on the new stove with cooking on the traditional stove using a range of criteria such as fuel use, fuel preparation, smoke emitted, cooking time, fuel tending, aesthetics, stove stability, and flavor of food cooked on the stove. Household members may also be asked questions to perceive whether they think the stove is appropriate for people of their socioeconomic status, will influence how others look at them, etc.

Conducting all of the research techniques provided in the WASHplus toolkit can take a fair amount of time and resources. At a minimum, those interested in promoting cookstoves in a given context should undertake a simple controlled cooking test with a local cook cooking a typical local meal to at least rule out inappropriate cookstoves, and a few focus group discussions to get initial feedback on cookstove features desired by the consumers. This type of research doesn't provide insight into changes in preferences over time, which has been shown to occur in many places,

but at least provides a snapshot of the appropriateness of a particular cooking technology in a specific context. Ideally, programs that are focused on achieving sustained adoption and impacts should consider longer-term consumer research options.

STOVE STACKING AND BARRIERS TO CONSISTENT, CORRECT USE

When a particular cooking technology meets some, but not all their needs, consumers often opt to use more than one technology in parallel, also known as "stove stacking," to maximize utility. For example, an improved stove might work well for staple dishes, but an LPG stove is much faster for boiling water to make tea in the morning, and the traditional stove is faster when the cook needs to prepare large amounts of food for special occasions, or animal fodder. Most of us do something similar, using multiple appliances such as ovens, microwaves, toasters, rice cookers and coffee makers. In addition, consumers may use different technologies at different times of year due to seasonal difference in fuel availability, or to meet heating needs in colder months. While this is a rational consumer behavior, stove stacking with lower-quality fuel/stove options limits the potential benefits of the better-performing technologies used. Preferences can change over time irrespective of seasonal differences. WASHplus consumer preference studies in Bangladesh and Nepal found declining preference for improved stoves compared to traditional stoves over time; a 7% drop over 4 months in Nepal, and a 34% drop over just 3 weeks in Bangladesh.

Finally, after-sales service, such as troubleshooting support, repair shops, warranty fulfillment and availability of replacement parts, is critical to ensuring that consumers **can** continue to use their new stoves over time, and don't abandon them because of an easily-fixed malfunction. It's important for product manufacturers and distributors to have ongoing, cost-effective ways for engaging with new and existing customers, to test new marketing messages, promotions and strategies, and gauge customer satisfaction (with service or products), to promote and maintain positive brand associations. The better that implementers can understand consumer preference, motivations/constraints and behavior, the better they can design products and interventions to more fully meet consumer needs. Understanding customer motivations and constraints also facilitates design and delivery of consumer education and marketing campaigns necessary both to build demand and promote correct use.

BEYOND PURCHASE: MEASURING USAGE AND ADOPTION

Cookstove manufacturers, distributers and program implementers can gain valuable consumer insights by tracking actual use of improved and traditional stoves during in-home trials, or post-purchase; usage monitoring is also often required for results-based financing, including carbon finance verification. In surveys, consumers routinely over-report their use of improved stoves, and under-report their use of traditional stoves. Stove usage monitoring sensors (SUMs), ranging from thermocouples to temperature-sensitive iButton data loggers, track changes in stove temperature to determine how often and for how long stoves are used. They are an objective, unobtrusive, quantitative method for assessing stove usage that reduces recall and reporting bias. Beyond tracking whether consumers use their stoves, identifying tasks for which consumers use and don't use their improved stoves can inform cookstove design and marketing around the most frequent and/or energy-intensive tasks, for maximum impact[1].

1. http://www.ghspjournal.org/content/2/3/268

Photo credit: AEST

MARKET-BASED APPROACHES AND FINANCING

Creating a market for clean stoves and fuels means getting the right logistics, incentives, financing and partnerships in place to reach even the most remote "last mile" users – a challenging task with no one-size-fits-all solutions. Innovative efforts to overcome these challenges are needed.

WHY IT MATTERS

Long-term sustainability of impacts requires development of thriving local markets for cookstoves and fuels that can continue to supply quality, consumer-focused products and services beyond donor funding timelines. Donor/project financial resources can be used to alleviate market barriers and encourage market innovation.

BEST PRACTICES

1. Reaching BOP consumers through a market-based approach is still a challenge, especially for highly spread out, rural consumers. Donors can spur innovative marketing and distribution approaches through grants aimed at trialing outside-the-box strategies.

2. Non-traditional distribution partners with large networks of potential cookstove customers, such as financial institutions, may be unwilling to risk their own funds to do projects in the cookstove sector. Funds for piloting new partnerships, coupled with technical assistance for new sector entrants can be effective at reducing the costs of market entry.

3. Retaining a trained, professional and highly motivated sales force is one of the largest challenges facing scale up. Donors can support sales agent and entrepreneur training and mentoring, and provide technical assistance to stove companies in developing innovative sales incentives.

4. Manufacturers, distributors and customers alike need sustainable, accessible sources of local financing. Determine what the most appropriate forms of financing are in your target market by investigating available financing options and identifying key gaps.

MARKET-BASED APPROACHES OVERVIEW

Getting the product right – in terms of performance and user acceptance – is important, but only one piece of the larger challenge in getting cleaner, fuel efficient stoves regularly used in homes. To make that happen you need:

- Reliable, established distribution channels to get the product from the manufacturer to the end user, which becomes increasingly difficult in 'last mile' areas, away from urban centers;
- Working capital for distributors to invest in stock from manufacturers to sell through their retail networks;
- A well-trained, supported, motivated, and incentivized sales force;
- Clear, pervasive, consumer-focused product marketing that informs consumers of the features, benefits and availability of the product;
- Financing options for consumers that make high quality, advanced stove and fuel products affordable through installment payments or other financing arrangements; and
- Partnerships established with local financial institutions, community savings groups, local retail kiosks, supermarkets, women's groups, and others with long-term ties to the market, community and consumer.

And all of this needs to happen while ensuring that margins are sufficient to create and sustain profitable, local enterprises that can continue selling increasingly higher quality products as they come on the market, without increasing the retail costs of the product so much that it can no longer compete with traditional or slightly improved options.

While complex, many of these challenges can be systematically addressed through employing the classic marketing mix of the "4 P's" – Product, Price, Place, and Promotion.

With support from USAID's WASHplus project, the Global Alliance for Clean Cookstoves developed a guide for conducting market research that provides a starting point for those interested in learning more about designing targeted market development interventions around these 4 P's.

CURRENT MARKET DEVELOPMENT EFFORTS

Various ongoing efforts supported through donors and impact investors are working to find context-appropriate solutions to these challenges globally. USAID's Developing a Sustainable Cookstove Sector (DSCS) project is one such project, working to develop sustainable cookstove markets that will lead to widespread adoption of clean, efficient cooking solutions through:

- Strengthening private commercial distribution of high-quality stoves
- Encouraging innovative partnerships locally for distribution and financing
- Increasing availability of local financing for consumers and enterprises
- Expanding consumer access through new distribution mechanisms.

Other major market-development efforts include the EnDev-funded Results-Based Financing mechanisms that have been established in multiple countries (including Kenya, Peru, Cambodia, Vietnam and others) to remove barriers to scaling up distribution of high-performing off-grid energy appliances, including cookstoves. These are done in partnership with GIZ, SNV, DFID and others. More on this is included in the "Enterprise Finance" section below. GIZ has been actively developing cookstove markets for three decades, through various country-level programs reaching sales of as many as 1.5 million stoves annually.

The Global Alliance for Clean Cookstoves has also been actively engaging in market development initiatives by funding interventions aimed both at facilitating supply, as well as demand. The Alliance has developed a suite of funding mechanisms designed to support enterprises at various stages of development, from early stage startups to mature businesses, with the goal of preparing a pipeline of opportunities for investment. To achieve this, it uses a combination of grants, patient capital and capacity building. The Alliance also works to catalyze demand and sustained use of clean and efficient cookstoves and fuels by supporting large-scale consumer facing communication campaigns aimed at raising awareness of the availability and benefits of cleaner cooking options and motivating purchase and consistent use. These campaigns employ a variety of channels, including mass media, mobile messaging, and interpersonal communication. The Alliance supported campaigns in Ghana, Uganda, Guatemala and Bangladesh in 2016, and plans to support additional interventions in Nigeria, Kenya and Bangladesh in 2017/2018. A partnership between the Global Alliance for Clean Cookstoves and the Government of Canada (2016 – 2021) is focusing on scaling up market development for efficient cooking solutions in Haiti.

Various governments are also currently leading large-scale market development efforts designed to increase uptake and use of cleaner, more efficient stoves and fuels. These include:

- The Indian government's National Biomass Cookstoves Program, under the Ministry of New and Renewable Energy, as well as its government led programs aimed at expanding access to LPG, such as the Pradhan Mantri Ujjwala Yojana initiative providing free LPG connections to women from low income households, under the Ministry of Petroleum and Natural Gas.
- Nepal's Clean Cooking Solutions for All by 2017 Initiative;
- Bangladesh's government-owned Infrastructure Development Company Limited (IDCOL) working with the World Bank to improve access and financing for 1 million stoves by 2018;
- The Ethiopian Ministry of Water, Irrigation and Energy's National Improved Cookstoves Program;

Photo credit: Winrock

- The Ghanaian Ministry of Energy and Petroleum's Rural LPG promotion program; and
- The Chinese government's adoption of clean cookstoves and fuels for 40 million by 2020 national program, among other ongoing large-scale government-backed efforts.

The World Bank Africa Clean Cooking Energy Solutions Initiative (ACCES), under the Energy Sector Management Assistance Program (ESMAP) is working to promote enterprise-based, large scale commercial distribution of stoves in several countries in sub-Saharan Africa, including Uganda and Senegal.

MARKET ASSESSMENTS, STUDIES AND STRATEGIES

For the past several years the Global Alliance for Clean Cookstoves has been commissioning a series of cookstoves market assessments and consumer segmentation studies in dozens of countries to determine the primary market drivers and barriers in each. These studies are all available on the Alliance Resource Page, which is searchable by country and type of assessment. Market studies generally provide an overview of the macro environment, local socio-economic profiles, types of stoves and fuels available in the market, state-of-the sector, main stakeholders, and recommendations. Consumer studies focus more on the demand for stoves and fuels locally, pinpointing which consumer segments are best suited/equipped to adopt clean and efficient cookstoves in each country, and identifying key insights for developing effective products and marketing strategies

Photo credit: Winrock

CONSUMER RESEARCH

Understanding what features and benefits consumers are willing to pay for, and how different payment structures can contribute to greater uptake is also a key area of market research. To this end, Willingness-to-Pay studies have been completed for different cookstove markets globally. The USAID WASHplus project conducted two willingness-to-pay (WTP) studies in Bangladesh and Nepal. Results from those studies, which are discussed in reports that are available on the WASHplus Resources page, found that consumer financing options were important in both countries, although not sufficient in and of themselves in Bangladesh. The USAID-funded TRAction project also commissioned research in Uganda on WTP for cookstoves, which tested the effects of different marketing messages on WTP and studied how different payment strategies impacted a consumer's WTP. They found that it was "extremely difficult to increase poor households' WTP using marketing messages alone" and that introducing various payment strategies (i.e., installments) had a much greater impact. It is important to note that different strategies may be needed in different cultural/geographic contexts, and amongst different consumer segments. Other organizations, including the World Bank and SNV, have also commissioned research on WTP and effective messaging.

MARKETING AND DISTRIBUTION STRATEGIES

Marketing strategies vary by country – the type of marketing that reaches and appeals to target consumers in Kenya may not reach or appeal to target consumers in India or Guatemala. The most effective methods for marketing also vary by consumer segments: women, men, urban, rural, low income, middle income, different age groups, users of different fuels and those cooking in different climates within the same country. Understanding the market is critical, and that includes knowing what type of marketing approaches have the most impact and reach in the areas you're working.

Hystra has been working to study and share lessons related to marketing and distribution at the BoP level, through webinars and reports available on their website. Hystra's publication Reaching Scale in Access to Energy investigates barriers and solutions to scale for market-based approaches offering cleaner energy access to low-income customers in developing countries. Shell Foundation has been working on market development activities for cookstoves since 2002, and in 2014 released a report on the main lessons from this work, including 6 barriers to growth and their approach to overcoming them. These include 1) the need for 'significant' early stage support; 2) understanding that early adopters aren't necessarily the BOP consumers; 3) the need for innovation across the value chain; 4) the need for financial solutions; 5) focus on talent development; and 6) the need for global networks. They also released, in 2013, a report on their lessons learned specifically related to social marketing efforts in the cookstove sector in India. SNV released Successful Distribution models for Clean Cookstoves in 2015 which draws from 10 case studies in Africa, Asia and Latin America and outlines key lessons for the establishment of last mile distribution chains for clean cookstoves.

More information on consumer-focused research to develop effective marketing efforts is included in the Consumer Preferences and Adoption section of this toolkit.

RECRUITING, TRAINING AND INCENTIVIZING SALE STAFF AND ENTREPRENEURS

Recruiting, training and incentivizing sales staff and entrepreneurs is also a key part of developing sustainable cookstove markets. There are still many gaps in our understanding of what factors best contribute to entrepreneurial success in the cookstove sector, and how to effectively train, recruit, incentivize and retain sales teams. Business models are still evolving, with many companies continuously experimenting with their strategies. Some of the most common models include:

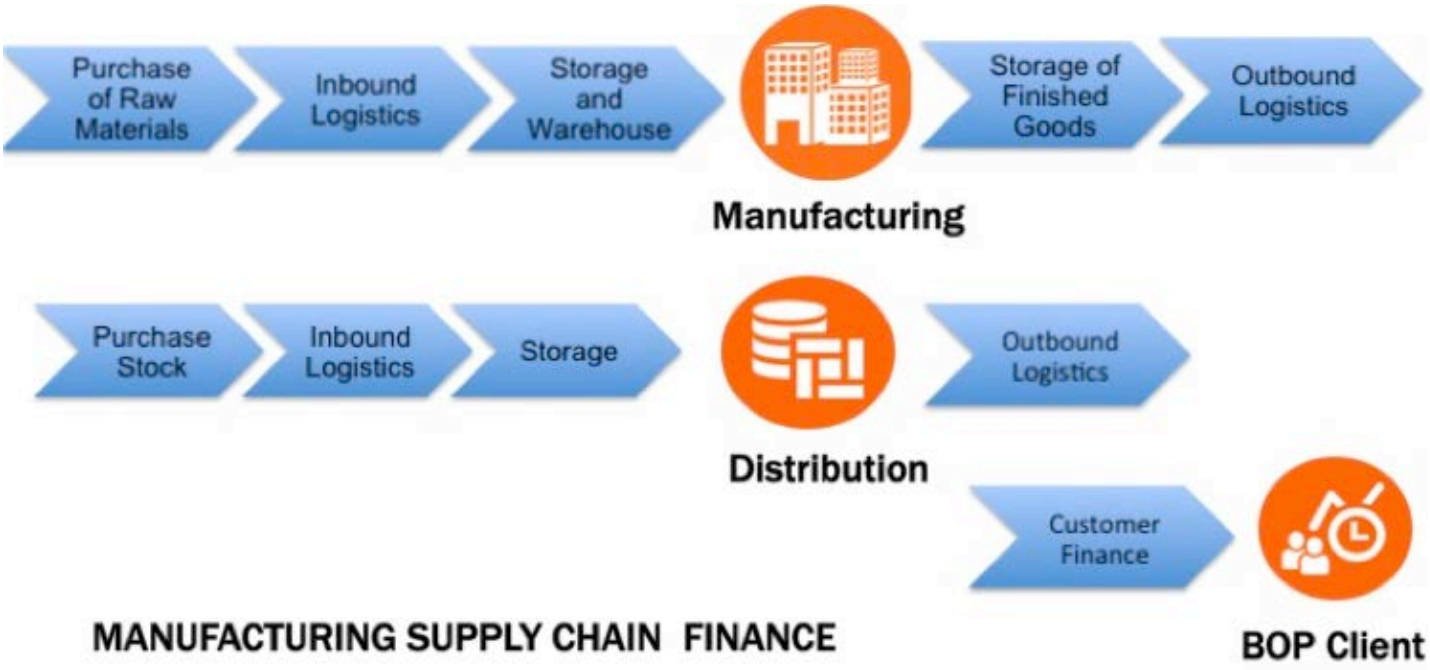
- Salaried sales staff / direct consumer sales.
- Commission payments or earned margins on stoves sold, independent agents working with or without consignment options.
- Salaried sales staff + commissions.
- Business to Business sales: salaried staff selling to supermarkets, corporations (corporate social responsibility), aggregator organizations (associations), third party distributors, or local retailers/kiosks.
- Sales through financial institutions, such as MFIs, credit cooperatives, commercial banks, savings groups and others.
- Promoters/village level entrepreneurs/women's groups working at community levels, earning margins on stove sales.

Training and incentives strategies for sales teams and promoters also vary greatly, with many organizations – given limited resources - providing only a basic introduction to the stove features and benefits, rather than comprehensive business training. Sales staff and entrepreneur training needs also vary by business model. Many companies are interested in recruiting and retaining higher numbers of women entrepreneurs and sales staff, given that the primary users of the stoves are women. A randomized controlled trial conducted by Johns Hopkins University, and implemented by ESVAK Kenya, studied the impact of agency-based empowerment[1] training on the business activity and sales of women entrepreneurs in Kenya. The study found that women entrepreneurs who received the agency-based training sold nearly 3 times as many improved cookstoves as men generally; men and women getting the enhanced training were 2.7 times more likely to be high sellers; and women and men who received the agency-based empowerment training were twice as likely to pursue sales leads and continue their business activities when faced with challenges. More on agency-based empowerment, including a fully developed curriculum for training cookstove entrepreneurs can be found at: http://cleancookstoves.org/resources/342.html.

Examples of strategies for recruiting, training and incentivizing sales staff were discussed during an EPA/Winrock webinar available here. Other strategies for retaining women sales staff and entrepreneurs are included as part of the Alliance's Scaling Adoption of Clean Cooking solutions through Women's Empowerment Resource Guide.

COOKSTOVE FINANCING

Financing is needed across the supply chain, and when financing is delayed or unavailable, the entire chain can break down. Arguably there are numerous critical investment needs for cookstove manufacturers requiring capital expenditures to set up or expand their businesses, such as machinery/equipment, facilities, logistics/transport and others. However, this section focuses on specific strategies to provide working capital to cookstove distributors, as well as end-user financing for consumers. Both of these requirements have been identified as missing components in the sector – see figure below.



1 Agency-based empowerment focuses on the internal factors that help create change; one's ability to make and control decisions that affect one's own life (involves self-awareness, self-confidence, etc.). This differs from traditional resource-based empowerment programs, which focus on external support.

CONSUMER FINANCE

Consumer financing can have a significant impact on willingness to pay (WTP) and uptake of advanced cookstoves and fuels, making it important to think creatively about ways to incorporate financing options into new and ongoing cookstove programs. Some common challenges around cookstove consumer financing include small loan sizes – cookstoves may be too expensive for consumers to purchase outright, but too inexpensive to warrant development of a specialized loan product for formal financial institutions, given the upfront and ongoing client due diligence and administrative costs. Because of the working capital constraints faced by manufacturers and distributors, they are often unable to provide credit terms to customers independent of financial partners. To compound the challenge, in many countries, financial partners that are willing to provide financing often lend at very high interest rates, making the products more expensive for BOP consumers. There are several initiatives and strategies being employed currently that are aimed at overcoming these challenges.

Some of the most common forms of consumer finance strategies include:

- Installment payments: Offering consumers the option of paying for the stove over a period of weeks or months, through upfront layaway payments or an agreed-upon schedule of post-sale payments, is a fairly common strategy. Drawbacks include that cookstove purchases can be impulsive (at market days, demonstrations etc.), and consumers are not always willing to pay through a layaway arrangement for a stove they won't receive immediately. For distributors with limited cash-on-hand, offering post-sale installment payments ties up critical working capital that is needed to purchase new stock or for other daily business operations. Without matching financing terms for the distributor to purchase stock, these arrangements can be difficult to scale.

- Employer payroll deductions: With larger employers, such as tea farms, flower farms, government-paid professions (e.g., teachers), payroll deductions are an important financing tool. Employers deduct a set amount from the employee's paycheck over time to pay back the stove. As deductions are taken out of paychecks before they hit the employee's account, they are seen as a very secure form of lending on behalf of the employer. Thus if employers have cash on hand to purchase bulk orders upfront, this arrangement can be very beneficial for the distributor. Some employers may still expect the distributor to provide payment terms whereby the distributor is paid back over time by the employer. In this case, the distributor still has the advantage of working with one intermediary rather than having to collect hundreds of small installment payments directly from the consumers, but similar working capital constraints emerge.

- Community savings groups and SACCOs: Community-level savings groups, often called merry-go-rounds or 'chamas' (East Africa) are micro-savings groups that pool savings from members for borrowing. Typically, members pool savings and the ability to borrow is rotated among members. These groups often serve as small informal lenders and cumulatively account for millions of dollars' worth of savings and loans in a range of countries around the world. The distributor benefits from working with community savings groups by receiving payment upfront. This means they are not forced to tie up working capital, or collect payments from numerous individual consumers.

- Savings and Credit Cooperatives (SACCOs) are larger, more formally regulated savings groups, which hold member savings and disburse loans for goods and services, such as education, housing, agricultural production and – increasingly – energy products. USAID has been working with the Kenya Union of Savings and Credit Cooperatives (KUSCCO) through the DSCS project to establish a loan facility dedicated to cookstove lending. The Jiko Safi 'Clean Stove' Fund lends money to SACCOs for on-lending to their members to purchase cookstoves.

- Micro-Finance Institutions (MFIs): MFIs are also formally regulated lenders that provide small loans (as well as insurance and other types of financial products). Typically, their clients are low income business people that are unable to access commercial financing. Successful MFIs often have large numbers of clients, and they are more likely to reach women borrowers than other types of institutions or distribution channels. A number of MFIs are currently developing their own distribution chains for improved stoves and other energy products. The USAID

REMMP and PACE-D technical assistance programs have supported a number of MFIs in India to develop energy-lending programs, such as ESAF in India.

- Mobile payments: Around the world, mobile payment options are becoming increasingly available as a means to pay for clean energy services. Kenya is a leader in establishing highly-accessible mobile payment systems, and offers M-Pesa – a pioneer in the mobile money transfer service sector, filling a void for the traditionally unbanked population. Through M-Pesa, consumers can add credit to their mobile wallet and transfer funds to buy goods and services, including cookstoves, from local retailers. M-Pesa is a branchless banking service that relies on agents, allowing it to penetrate to last mile consumers in rural areas with strong cellular networks. Other mobile payment apps include Equity Bank's Equitel platform, that provides an online energy loan called the EcoMoto loan, offering pre-approved Equity customers the ability to obtain a loan instantly from authorized Equity Agents using their smartphone app.

ENTERPRISE FINANCE

Enterprise financing is needed at both the distributor and the manufacturer links in the cookstove supply chain. However, because most companies in the sector are still start-ups, or young (growth) companies, they face constraints in securing commercial financing. Typically, this is because they are unable to meet collateral requirements, and do not have an established track record of borrowing and repayment.

- Working capital financing: One of the biggest barriers to scaling up successful cookstove distribution businesses is access to finance, particularly working capital finance. Margins for most cookstove distributors can be fairly small, and adding any sort of payment terms for retail partners or consumers further ties up the working capital available to purchase new stock. To alleviate these constraints, the USAID DSCS project established a revolving loan facility in Kenya through local financial institution Micro Enterprise Support Programme Trust (MESPT) to provide working capital to cookstove distributors (including MFIs acting as product distributors). Some challenges and benefits of partnering with formal financial institutions are included in the DSCS Briefing Notes. The Global Alliance for Clean Cookstoves is also developing a working capital facility with Deutsche Bank's Community Development Finance Group that will provide loans and loan guarantees to enterprises in the clean cooking sector. The US Overseas Private Investment Corporation (OPIC) has provided cookstove enterprise finance for large-scale international stove enterprises in the form of debt financing, which has provided a critical injection of capital into the sector.

- Impact Investors: Impact investment companies have also contributed to cookstove enterprise financing efforts. The Calvert Foundation's Women Investing in Women Initiative (Win-Win) is a gender-focused investment program, which provides financing to social enterprises, including cookstove companies, that support women's empowerment and advancement. Calvert has invested in manufacturers and distributors that provide clean energy technologies to off-grid communities. Acumen is a pioneer in investing in energy and other social enterprises serving BoP consumers, as part of its social impact investing initiatives, and made its first two investments in the cookstove sector in 2015 by providing investments in BURN Manufacturing and Biolite.

- Results-based financing: One of the newest forms of enterprise finance in the clean cooking sector is results-based financing (RBF). RBF mechanisms provide incentives for performance, usually around reaching a certain scale (e.g., of sales, products produced). RBF mechanisms can also sometimes be linked to climate and health results. DFID, through the EnDev program, has been rolling out RBF mechanisms for cookstoves (and solar) in multiple countries worldwide. In Kenya, for example, eligible financial institutions are working with EnDev to scale up distribution of high-performing cookstoves, and will receive payments for hitting certain sales targets. In Cambodia and Vietnam, EnDev is launching 'The Stove Auction', which prequalifies certain stoves (purchased from manufacturers at a set price) to be auctioned to local distributors, providing financial incentives to distributors who purchase the auctioned stoves. The drawback to RBF programs is that they can't necessarily address the working capital constraints described above, but when combined with existing working capital finance, there is real potential to scale.

Photo credit: Project Gaia

CROSS-SECTORAL COLLABORATION

The potential impacts from widespread adoption of cleaner, more efficient cookstoves and fuels are most often linked directly with energy, health and environment objectives, but can also extend beyond these sectors. Cleaner, more efficient stoves and fuels can support advancement of objectives in gender and socio-economic programs, humanitarian response and protection interventions, and commercial cooking/school feeding programs as well.

WHY IT MATTERS

Cleaner and more efficient stoves and fuels can support wider agency priorities and amplify impacts around gender, humanitarian response and protection, and school feeding or other types of commercial cooking, but only when proper planning or resources are allocated.

BEST PRACTICES

1. Remember that, as the primary users of household energy, women can play a key role throughout all aspects of the cookstove and fuels value chain. The resources included here around integrating and empowering women to participate in the cookstove value chain can be extended to other entrepreneur development efforts as well.

2. During program planning, consider that women and men experience the impacts of household energy changes differently, and be sure to use gender-informed strategies for behavior change (e.g., technology or fuel switching), promotion and marketing efforts.

3. It's critical to prioritize, and carefully plan for, energy needs in humanitarian response and protection efforts. Various handbooks and guidance materials are available to help you integrate energy access into humanitarian interventions. Energy needs are even more pressing in vulnerable, displaced populations.

4. Institutional stoves have the potential to deliver major cost or time savings for commercial cooking or school feeding programs, but commercial markets for institutional stoves remain largely underdeveloped. Especially in the case of fuel switching, be sure to devote sufficient resources to training cooks and developing distribution chains and repair and maintenance service channels.

GENDER-BASED APPROACHES AND IMPACTS

"Women are disproportionately impacted by dirty and inefficient cooking practices and reliance on biomass for fuel. Yet women are not just victims. They play a crucial role in the widespread adoption and use of clean cooking solutions because of their central responsibility for cooking and managing household energy." Scaling Adoption of Clean Cooking Solutions through Women's Empowerment: A Resource Guide – Global Alliance for Clean Cookstoves (Alliance).

Because women often manage household energy resources – with women playing critical, multidimensional roles as cookstove and fuel users, producers, sellers and adoption influencers – gender considerations need to be woven throughout the entire cookstove and fuel value chain, especially given that women may lack mobility and the ability to control household finances. Likewise, incorporation of cookstove and cooking fuel issues into gender-focused programming can support the further advancement of women's empowerment and gender equity goals. To this end, the Alliance developed a resource guide for scaling the adoption of clean and efficient cookstoves and fuels through greater integration of women in the entire cookstove and fuel value chain: product design; production; finance; distribution; and after-sales services. This guide includes best practices for engaging women in each of these value chain segments as well as universal best practices to engage women; for example conducting a gender analysis to understand community gender roles and dynamics, and scheduling times and locations of meetings and activities around women's availability. Examples of specific value chain best practices include gathering feedback on product design from women via in-home trials; integrating livelihood opportunities for women in production processes; educating women's groups on how to access consumer finance as a group; and using gender-informed marketing messages and methods, and women and girl-focused community groups for awareness raising.

In 2014, the Alliance commissioned a randomized controlled trial, led by Johns Hopkins University (JHU) and implemented by ESVAK Kenya, to determine the impact of agency-based empowerment training on cookstove entrepreneur sales in Kenya (for both men and women). Unlike traditional resource-based empowerment programs that provide externally-focused support (skills, education, financing), agency-based empowerment focuses on enhancing an individual's cognitive capacity to create and focus on his/her goals, and prepares him/her to effectively take advantage of opportunities when they arise. The JHU Kenya study found that women entrepreneurs who received the agency-based training sold nearly 3 times as many improved cookstoves as men generally; men and women getting the enhanced training were 2.7 times more likely to be high sellers; and women and men who received the agency-based empowerment training were twice as likely to pursue sales leads and continue their business activities when faced with challenges. Based on these findings, the Alliance contracted the Visionaria Network to develop a full curriculum with JHU, focused on the specific needs and challenges faced by women cookstove entrepreneurs, but relevant for both men and women, that builds key skills in business, agency-based empowerment and leadership. That curriculum, called the Empowered Entrepreneur Training Handbook, is being rolled out globally through the USAID Developing a Sustainable Cookstove Sector project. The handbook walks organizations through a Human-Centered Design process that creates a tailored program to fit the individual needs of women and men working as cookstove entrepreneurs, including considerations for setting up the training agenda to ensure equity in participation. Additional relevant research findings are included at the end of this page.

As primary cooks, women face disproportionate direct health impacts. There are also serious safety burdens – both in traditional cooking and fuel collection practices – that are overwhelmingly borne by women. These include burns, eye irritations, and back injuries from tending fires, as well as the risks of harassment, assault, injury or rape during fuel collection trips. The Women's Refugee Commission has long been an important resource for information and guidance around prevention of gender-based violence in refugee settings, including related to fuel collection: https://www.womensrefugeecommission.org/gbv/firewood.

OTHER RESOURCES

http://www.energia.org/cms/wp-content/uploads/2015/06/94-What-motivates-women-to-buy.pdf

http://www.sciencedirect.com/science/article/pii/S1877343513000389

HUMANITARIAN RELIEF AND PROTECTION

AN ESTIMATED "20,000 DISPLACED PEOPLE DIE PREMATURELY EACH YEAR FROM RESPIRATORY ILLNESSES AS A RESULT OF HOUSEHOLD AIR POLLUTION CAUSED BY BURNING WOOD, CHARCOAL, KEROSENE AND OTHER FUELS INDOORS. SHELTERS CATCH FIRE AND CHILDREN ARE SOMETIMES ACCIDENTALLY POISONED BY DRINKING KEROSENE" – MOVING ENERGY INITIATIVE

Clean, efficient stoves and fuels can have life-changing impacts in refugee and IDP settings, where access to fuelwood is often extremely scarce, and the need for safer cooking options is an urgent necessity. The Global Alliance for Clean Cookstoves provides an overview of cooking in humanitarian settings on its website, as well as a compilation of innovative cooking and fuel interventions in this sector. The Alliance's clean cooking catalog can serve as a resource for humanitarian partners procuring stoves and making technology selections for crisis-affected people. The Alliance also Co-Chairs the Safe Access to Fuel and Energy (SAFE) Humanitarian Working Group, a consortium of partners who work to facilitate a "more coordinated, predictable, timely and effective response to the fuel and energy needs of crisis-affected populations," specifically those concerning heating, lighting, cooking, and powering. The SAFE Working Group is a global effort to improve coordination and information sharing, commission research, provide technical support and guidance for implementation, build human resource capacity, conduct advocacy, and mobilize resources. SAFE holds an annual training for humanitarian implementers and energy sector stakeholders to learn how to implement energy access interventions in humanitarian settings. Additionally, a SAFE expert roster is under development, which will include a list of experts that can be deployed to address energy issues in emergencies, as well as in protracted settings. That roster will be publically available on the SAFE website once completed. The SAFE Working Group's website has an extensive resource library, which includes guidelines and recommendations, toolkits, webinars, project evaluation reports, workshop proceedings, and research publications that range from camp-specific and country-level to global in scope.

One global-level resource is the World Food Program's Handbook on Safe Access to Firewood and Alternative Energy, which is a how-to guide on implementing energy projects in humanitarian settings. This is also used to help WFP staff in designing and implementing effective energy approaches. While not all agencies are prioritizing energy, UNHCR's Global Strategy for Safe Access to Fuel and Energy (2014 -2018), covers five main strategic objectives around this issue: 1) better integrate energy into emergency preparedness and response activities, 2) develop country-level strategies, 3) improve household-level access to energy, 4) improve energy access for schools and other institutions, and 5) establish and manage woodlots for fuel provision.

Another available resource is the "Fuel-efficient stove programs in humanitarian settings" toolkit, developed by USAID's Energy Division and Office of Foreign Disaster Assistance (OFDA). The toolkit was designed to help guide organizations through the assessment, planning, implementation and M&E processes of a stove activity in humanitarian contexts.

Finally, the Moving Energy Initiative (MEI), a partnership between Chatham House, DFID, UNHCR, the Norwegian Refugee Council, Practical Action Consulting and GVEP International, provides access to additional resources and conducts research on this topic. MEI has assessed the key challenges related to energy access in humanitarian settings as: 1) insufficient attention (energy access comes behind food, shelter and medical care); 2) insufficient data or consistency in the way energy data is recorded; 3) insufficient long-term funding; 4) insufficient expertise – no designated energy 'cluster'; 5)

Photo credit: Winrock

issues related to refugee status and rights; and 6) practical problems of where camps are located, and lack of security. They also offer several strategies for overcoming these challenges and are members of the SAFE Working Group.

COMMERCIAL COOKING AND SCHOOL FEEDING PROGRAMS

Efficient institutional stoves for small scale enterprises or schools can yield significant fuel savings, which translate directly into monetary and/or time savings for the institution, depending on whether fuel is purchased or gathered.

Institutional stove programs are usually donor-funded, even though they can have very short pay-back times; this limited commercial market can translate into limited after-sales service. However, there are a few examples of where institutional stoves are sold on a commercial basis. In Uganda, International Lifeline Fund (ILF) has set up a credit framework where various institutions such as schools, hospitals, or prisons purchase stoves through a payment plan. Typically, schools with a student body over 200 are able to save 18+ tons of firewood, which is equivalent to approximately US $1,000 annually. This financing framework facilitates a path for institutions that recognize a need for fuel efficiency, but do not have the startup capital to procure such products.

Photo credit: Winrock

Starting in 2010, The World Food Programme (WFP) has been undertaking an ambitious program to provide locally-produced institutional fuel efficient cookstoves to 2,000 schools in Ethiopia, aiming to reduce each school's fuel consumption by 50%. Various UN agencies have also purchased internationally-produced institutional stoves for use in humanitarian settings, including 200 stoves for school feeding programs in the Darfur region serving approximately 80,000 children with a stove that can see as much as 75% fuel savings.

Institutional stoves can also be used for small-scale production of products such as shea butter (see collaboration between GIZ, UNDP, L'Occitanne and shea butter women's cooperatives in Burkina Faso) or fish smoking (see SNV work in Ghana). These types of industries, especially at the artisanal/small-scale cooperative level, can be very fuel-intensive. By replacing traditional stoves with improved institutional stoves designed specifically for these uses, producers can save money and time as a direct result of fuel savings.

Various donors and implementers are piloting and investing in institutional stove technologies that can burn alternative fuels such as ethanol, briquettes, or pellets. Gaia Association is working with Babington Technology in Gambella Refugee camp in Ethiopia to introduce institutional stoves which can work with any liquid fuel. In Burundi, WFP is converting over 200 schools from using firewood to using locally made briquettes. In Haiti, WFP has worked with ILF to introduce institutional stoves fueled by locally made briquettes, and has also been exploring LPG, given the urgent need for charcoal alternatives there. Schools in Haiti with 400 students can spend as much as $300 monthly on fuel. The USAID Improved Cooking Technology Program (ICTP) in Haiti worked to reduce charcoal consumption, which is very demanding on scarce forest resources, in school canteens, orphanages and among street food vendors through introduction of institutional LPG stoves. ICTP was able to convert 239 schools to LPG, 39 orphanages, and 2270 food vendors to LPG from charcoal. Although initial conversion was successful, longer term adoption could not be measured during the project timeframe, and for vendors, maintaining regular LPG use can be difficult due to challenges related to LPG supply and distribution.

The pros and cons of different alternative fuels are discussed fully in the Technologies and Fuels section of this toolkit. Before rolling out any fuel switching program, it's important for donors and implementers to test the fuel efficiency and emissions, as well as market demand, of the stove/fuel combination they plan to promote. It is also critical to note that, with introduction of any institutional stove technology, institutions require a) substantial investment in training and follow up as it take time for cooks to adopt these new technologies, b) a repair and maintenance system must be in place otherwise users lose confidence and will stop using the stoves, c) a baseline survey before and after the intervention should be done to better measure the intervention impact. In case of feeding programs, it is vital to know the amount of food per student served daily, amount of fuel, cooking time duration, and number of cooks before selecting a stove/fuel combination to promote. Individual program details aside, it is important to develop a comprehensive monitoring and evaluation framework to properly assess the needs of, and impacts on, the users that will be benefitting from the stove intervention.

ENVIRONMENTAL CONSERVATION (FORESTRY / BIODIVERSITY)

Although improved cookstoves and fuels have not been a primary focus of Reduced Emissions from Deforestation and Forest Degradation (REDD+) programming to date, according to a 2015 report by Climate Focus for the Global Alliance for Clean Cookstoves, a quarter of the gross emissions from deforestation in the tropics is attributable to woodfuel emissions from household cooking. They found significant variance by country, but based on a review of existing data and literature sources, discovered that in certain regions – such as East Africa – woodfuel emissions can be "50% or more of nationally reported GHG emissions." They recommend greater linkages between REDD+ and cookstove programming, sharing knowledge and improving accounting methodologies between REDD+ and woodfuel consumption.

Unsustainable (non-renewable) biomass fuel use for cooking and heating can increase pressures on forests and contribute to local forest degradation. There is uncertainty and variance in the percentage of biomass used for cooking

that can be considered "non-renewable." A 2013 report "Assessing the Climate Impacts of Cookstove Projects: Issues in Emissions Accounting" by the Stockholm Environment Institute (SEI) explains that part of that uncertainty arises from a lack of standard approaches for quantifying the fraction of non-renewable biomass (fNRB). Because of this, estimates used for cookstove carbon finance project documentation have relied on UNFCCC default factors based on national-level data for total wood harvesting (without any distinction between fuelwood and timber harvesting), and have been generally higher (80%+) than recent evidence shows from a 2015 Yale / National Autonomous University of Mexico (UNAM) study. That study estimates that about 27-34% of wood fuel harvested worldwide can be considered 'unsustainable,' as defined by the amount of harvesting exceeding regrowth. The authors raise an important point about regional and national variability requiring additional study, and point to 'hotspots' in South Asia and East Africa where over half the wood use is unsustainable. Other tools for estimating fraction of non-renewability include the Woodfuel Integrated Supply/Demand Overview Mapping (WISDOM) methodology, which looks at spatial variations of biomass at the subnational level. WISDOM requires data inputs which may be unavailable to certain project developers, and has greater applicability in rural areas where people gather fuel for cooking, rather than urban centers where fuel is brought in and sold.

Potential project interventions specifically related to forestry and biodiversity efforts include:

- Introduction of alternative fuels (liquid fuels, briquettes from agricultural or other biomass waste products, pellets, etc.)
- Creation of sustainable wood lots for fuel collection
- Introduction of improved cookstoves that decrease firewood and/or charcoal use.
- Sustainable charcoal production

Monitoring uptake and use of these interventions is critical to identify whether or not they are having the intended impact on forest resources. Monitoring tools available are included in the M&E section of this toolkit.

Some examples of program integration of cookstoves into forestry and biodiversity objectives include:

- The USAID Central Africa Regional Program for the Environment (CARPE) is focused on sustainable forest management, biodiversity conservation, and climate change mitigation activities in the Congo Basin through improving conservation monitoring and natural resource management. Under this program, in addition to community-managed tree plantations, local women's associations were supported to produce and promote improved cookstoves in households around Virunga National Park as a way to reduce consumption of biomass for cooking. CARPE partner WWF promoted the production and sale of improved stoves, resulting in 25,000 stoves sold from 2009 – 2013. CARPE also provided improved stoves in IDP camps.
- The Nature Conservancy has programs focused on developing support systems for wood fuel lots and promote fuel-efficient stoves in Haiti among other countries.
- A Gold Standard registered project in the Sundarbans National Park is working to achieve biodiversity protection goals through disseminating Top Lit up Draft (TLUD) stoves. Other gold standard and CDM carbon offset projects with similar biodiversity goals can be found in the Global Alliance's "Catalog of Carbon Offset Projects and Advisory Service Providers," which includes a short profile on all current (as of 2015) carbon offset projects involving improved cookstoves and fuels.

ADDITIONAL RESOURCES:

Drigo R, Bailis R, Ghilardi A, Masera O 2015. WISDOM Karnataka - Analysis of woodfuel supply, demand and sustainability in Karnataka, India.

Drigo R, Bailis R, Ghilardi A, Masera O 2015. WISDOM Kenya - Analysis of woodfuel supply, demand and sustainability in Kenya

Drigo R, Bailis R, Ghilardi A, Masera O 2015. WISDOM Honduras - Analysis of woodfuel supply, demand and sustainability in Honduras.

Masera O., R. Bailis, R. Drigo, A. Ghilardi and I. Ruiz-Mercado 2015. Environmental Burden of Traditional Bioenergy Use. Annual Review of Environment and Resources 11/2015; 40(1). DOI:10.1146/annurev-environ-102014-021318.

Photo credit: Winrock

MONITORING AND EVALUATION

Because of their cross-sectoral nature, cleaner and more efficient cookstoves and fuels have the potential to impact a number of different development priorities. However, varying levels of success and complex determinants of effectiveness of such programs have led to a growing recognition of the need to prioritize monitoring and evaluation (M&E) to enable informed decisions at program and policy levels.

The M&E of the impacts and outcomes of programs promoting the uptake and use of cooking technologies and fuels covers not only stove and fuels performance testing, but also consumer preferences/willingness to pay, sales tracking and other business indicators, usage/adoption, health and environmental impacts, as well as social impacts.

WHY IT MATTERS

Developing robust monitoring and evaluation systems enables you to understand the impact of your work, and make informed decisions at program and policy levels. It's also critical for reporting aggregated results agency-wide, and reporting to Congress.

BEST PRACTICES

1. First, identify the impacts you want to achieve. Monitoring and evaluating health, environment, business and social impacts all require different tools and approaches.
2. Make sure the technology and fuel you choose to promote/support can deliver your desired impacts. Various protocols exist to evaluate cookstove performance with respect to fuel efficiency, emissions, safety, and durability – make sure the stove/fuel combination has been tested by a reputable testing organization/lab before dissemination at scale.
3. Find out if the stove / fuel is capable of meeting consumer needs (both immediate and long term). If the consumer doesn't use the stove, you won't get the impacts!
4. Sales are an important indicator, but for long-term impact monitoring, be sure to include sufficient resources to look at other key adoption and social impacts!

Included in this toolkit are descriptions and links to some of the methodologies and tools available for monitoring clean cooking programs, divided by:

- M&E for stove performance
- M&E of stove/fuel sales
- M&E on consumer behavior and its determinants
- M&E of social and well-being impacts.

The number of tools available exceeds the scope of this toolkit, but more information on various tools not included here can be found in the Global Alliance for Clean Cookstoves' "Impact Assessment Tools and Resources Guide." More information on the HAPIT tool for assessing health impacts is included in the "Research and Evidence on Health" section of this toolkit.

EVALUATING COOKSTOVE PERFORMANCE

Standardized laboratory and field-testing protocols for testing stove performance (fuel efficiency, total emissions, indoor emissions, and safety) have existed for over a decade, but international efforts to harmonize the various existing protocols, and increase the use and accessibility of third-party testing centers is relatively new (More information is provided in the Standards and Testing section). The current available laboratory and field testing protocols and their appropriate uses are described below.

MEASURING FUEL EFFICIENCY

Three internationally recognized and standardized tests to measure the fuel efficiency of cookstoves are the Water Boiling Test (WBT), the Controlled Cooking Test (CCT), and the Kitchen Performance Test (KPT). The laboratory-based WBT is the most easily controlled of the three, allowing for comparison between stoves. This is usually the first line test carried out during stove development before introducing a product to the market. The CCT uses a controlled field environment to assess the performance of stoves relative to the traditional baseline option, and consists of multiple cooks cooking a typical local meal (using exact quantities of the same ingredients) multiple times for each stove tested. The KPT produces a more 'real- world' estimate as it measures the impact of the introduction of the stove on all household fuel use[1], meaning that it takes into account not just the intervention stove performance, but also the degree to which consumers displace their traditional cooking option. This test is carried out in a larger number of households once the stove has shown positive results using the WBT and/or the CCT. More detail on these and other testing protocols are available here: http://cleancookstoves.org/technology-and-fuels/testing/protocols.html.

EMISSIONS MONITORING

For health and climate-focused programming, emissions monitoring is essential to track effectiveness and inform program planning. Small particles ($PM_{2.5}$) and carbon monoxide (CO) are the most commonly measured pollutants, as they are widely accepted to pose the greatest health risk. Following the distinctions made in the interim international standards tiers of performance, emissions are often categorized either as total emissions (all pollutants coming from the stove) or indoor emissions (the amount of pollutants that the stove produces indoors, not including those exiting through a chimney). For climate-focused programs, total emissions is an important indicator, whereas health-focused programs may be more interested in indoor emissions. That said, even pollutants that are carried out of the home through a chimney still have health impacts by re-entering through an open window, or accumulating in outdoor environments – especially in tightly packed communities. Other factors taken into consideration when assessing household air pollution include ventilation rates, the size and type of kitchen, the mix of stoves and fuels used, the number of people cooked for, lighting, and other indoor sources of pollution, such as emissions from kerosene lighting and cigarettes.

Emissions monitoring is most often done in conjunction with the other testing protocols described above, and can be done in both lab and field settings. The Water Boiling Test, for example, has a section on emissions testing as part of the formal protocol. Due to the complex procedures and equipment required to collect robust informative data, it is recommended that any emissions testing is carried out by a professional testing lab (such as the Regional Testing and Knowledge Centers) or other testing-focused organization/institution.

1 http://cleancookstoves.org/technology-and-fuels/testing/protocols.html

Photo credit: Clioma

SAFETY

In addition to fuel efficiency and emissions, safety is the only other metric currently included in the interim international standards for stove testing. Safety considerations for cookstoves and fuels are primarily focused around preventing burns and house fires (tipping, fuel containment, surface temperature, accessible flames), but also include evaluating sharp edges and other possible hazards. The internationally recognized Biomass Stove Safety Protocol is available on the Alliance protocols page. It's important to note that this safety protocol was created specifically for biomass stoves, and other important safety considerations for non-biomass stoves are not covered here (e.g., LPG canister erosion issues, prevention of leaks from gas or liquid fuel stoves).

DURABILITY

The durability of the stove can have a significant impact on the other elements of stove performance described above. As a stove deteriorates, so can its ability to perform optimally in terms of fuel efficiency, emissions and safety, which in turn impacts consumer perception and use as well as willingness to repair and replace the stove. Stove durability can be affected by the duration of use, the frequency of use, the type of fuel used, as well as other factors. A household stove used for institutional cooking will wear out sooner than its expected lifetime. Charcoal from distinct regions in the same country (in-land areas vs. coastal areas) can have different effects on stove longevity. Various forms of durability testing can be carried out, and differ by the stove model, construction materials, and expected use. Durability tests range from simple tests that can be done in the field, to sophisticated durability testing requiring an advanced laboratory setting. Colorado State University and the Global Alliance for Clean Cookstoves have created the first publically available comprehensive durability protocol, the newest of the protocols described here, which is available on the Alliance protocols page. A webinar on Cookstove Durability Testing, organized by US EPA and Winrock International, provides more examples.

SALES TRACKING

Sales tracking is a key project monitoring component to not only follow and react to trends in stove sales but also to carry out customer analysis allowing for enhanced customer relationship management and after-sales service provision (including warranty fulfillment). Sales databases can also support monitoring of sales agent performance, business growth indicators and provide important information for carbon financing programs. Sales tracking software is readily available and can be linked with mobile monitoring technologies that allow for easier and more accurate collection and automation of stove sales data, using simple SMS data capture tools, GPS location services, smart phone or tablet applications, and cloud-based information storage. A common sales tracking software is Salesforce, but other similar platforms exist, which can be customized to the specific needs of a company or donor, and are available and used by cookstove companies globally.

EVALUATING CONSUMER BEHAVIOR AND ITS DETERMINANTS

M&E for cookstove and fuels programs extends beyond the performance of the technology itself. Unless fully incorporated into household stove use patterns, even the most efficient, clean stove cannot achieve impact. It is therefore essential to measure and understand consumer behavior and its determinants related to cleaner, more efficient stoves. There are many tools available to support this M&E.

STOVE USE MONITORING

An emerging theme in the clean cooking sector is stove adoption, which is described in more detail in the "Consumer Preferences / Adoption" section of this toolkit. Even the best performing stove will not have the desired impacts unless it's being used consistently and correctly in homes. The extent to which consumers use a certain stove depends on many factors, including (but not limited to): how well it cooks staple foods, ease of use, familiarity, and fuel costs. Stove stacking, using multiple stoves or fires to meet the household needs, is prevalent worldwide and in many contexts cleaner, more efficient stoves are used side by side with traditional stoves and open fires. Even minimal use of an open fire or rudimental traditional stove can quickly result in exposures to emissions that exceed WHO guidelines (see Health section of this toolkit for more information and references) . Stove use can be assessed using quantitative survey methods but recent field data suggests a pattern of under reporting of use of traditional devices and over reporting of intervention stoves. Stove use monitoring systems (SUMS) eliminate the effect of recall and reporting bias by providing an objective measure of stove use patterns including an indication of traditional stove displacement.

SUMS record stove temperature at regular intervals to determine how often and for how long stoves are alight. SUMs can monitor multiple stoves in the same household to assess the proportion of cooking made up by different fuel/stove combinations. SUMS allow tracking of cooking events, length of cooking, and changes in use by season or community over an extending duration allowing for understanding of the initial uptake and use and then the longer term usage patterns.

New SUMS devices and analysis tools are coming on the market regularly. Prices range from approximately $20 - $200 per system, depending on functionality (i.e., battery life, memory, temperature range, sampling rate, wireless vs. manual data transmission, # of stoves monitored at once, air quality monitoring capability). **Some of the currently available stove monitoring devices include:**

- Maxim iButtons: small data-logging thermometers attached to stoves. (e.g., with special high temperature tape, embedded in the stove itself, or attached with a specially-made metal or wood holder). Various open-source data analysis software options are currently under development.
- NexLeaf Analytics StoveTrace Sensors: wireless monitoring system attached to the stove, transmits data in real-time through cellular network. Comes with own data analysis software.
- SWEETSense: wireless thermocouple and air quality (CO/CO_2) monitoring, attached to the stove, transmits data in real time through cellular or wifi networks. Comes with own data analysis software.
- kSUMS: data-logging thermocouple, can simultaneously monitor multiple stove if in close proximity.
- A-SUM: sensor monitors temperature, USB voltage, fan speed, and pot presence. Created by UC Berkeley with support from USAID to measure use of fan / thermoelectric generator stoves. Used with open source data analysis software.
- Infrared thermocouples: mounted in homes near open fires. Various brands available.

Different SUMS serve different purposes and there are advantages and disadvantages to each. It's best to first determine your primary objectives, where the study will take place, available budget, staff capacity and what type of stoves you are monitoring before selecting a specific SUMS.

A SUMS protocol for iButton deployment is currently under development by the Global Alliance for Clean Cookstoves in conjunction with the National Autonomous University of Mexico (UNAM). When finalized it will be made available on the Alliance protocol page.

CONSUMER PREFERENCE MONITORING TOOLS

Determining the most appropriate stove technology for a specific context can be a complex process which requires time and resources. There is no one stove/ fuel combination that will meet the needs of all cooks, even within a country or region. As mentioned elsewhere in this toolkit, it is critical that target consumers are brought into stove design and marketing decisions and processes. Any potential barriers to access, uptake and use of the new stove need to fully understood and if possible addressed. Consumers will only purchase and use, and especially exclusively use, cookstoves that fully meet their cooking needs and priorities. This means regular, effective evaluation of consumer perceptions and preferences is essential for any program.

The USAID-funded WASHplus project developed a tool for consumer research, including consumer preference testing, using Trials of Improved Practice (TIPs) methodology, which is available at http://designlab360.org/washpluscookstovetoolkit/. The World Health Organization Catalogue of Methods is another good resource for tips and tools on evaluating adoption and market development of household energy and health interventions. Other tools and methods include focus groups, individual interviews, household trials, or market demonstration events. The USAID Fuel-Efficient Stove Programs in Humanitarian Settings Toolkit also includes sample survey forms and guidance for assessing appropriate interventions based on consumer needs.

Photo credit: Winrock

QUALITATIVE MONITORING METHODS

Qualitative methods are included in several of the above-mentioned protocols and tools, but it's worth emphasizing here that they play an important role in understanding consumer behavior, satisfaction and impacts. Qualitative methods tell us how and why consumers decide to purchase or use technologies, and can work to provide important context to explain quantitative data. The most informative M&E methods for cookstoves and fuels programming include a mixed method approach, which incorporates both quantitative and qualitative methods. Qualitative methods include direct observation, focus group discussions, semi-structured interviews, and participatory methods using channels such as diaries, art, and photography.

Focus group discussions are generally undertaken with groups of 6-10 people, and are useful in exploring consensus and diversity of views around a list of themes and issues. They are facilitated in a flexible way to allow the group to explore new topics as they arise. Group dynamics are important to consider (e.g., separate sessions for men and women). Focus groups can employ other tools such as mapping and ranking exercises to aid discussion. Cookstove manufacturers, researchers and other types of implementers can get important consumer insights from these types of focused but flexible group discussions. Semi-structured interviews follow a similar flexible format, but may be more appropriate when individuals are not comfortable speaking in front of others, particularly around sensitive subjects. Guides for qualitative research can be found at LINK. Before organizing a focus group, it's important to consult with someone that has extensive experience in the field conducting these types of research.

Photovoice is a participatory method, wherein participants are asked to photograph their daily lives and communities along research themes. This allows the researcher to capture images and information that might be otherwise missed, and provides insights into what participants value most. The Cooking and Pneumonia Study (CAPS) in Malawi used this technique in their randomized controlled trial of advanced cookstove interventions to prevent pneumonia in children under 5 in rural Malawi.

SOCIAL IMPACT MONITORING

For the purpose of this toolkit the term social impacts includes impacts related to individual livelihoods, social and economic empowerment, household-level social and economic well-being, and time savings, among others. Social impact monitoring is the focus of one of the ISO working groups, included in the global standards discussions. The Alliance and the International Center for Research on Women (ICRW) have developed an M&E framework to measure socio-economic impacts in the clean cooking value chain. It includes a conceptual framework, indicators, surveys, and detailed guidance notes to measure impacts such as time, income, livelihoods, and empowerment. It is currently in its final phase of field testing and once finalized, it will be made available on the Alliance website.

Social impact investors have developed their own monitoring tools around determining these sorts of impacts. Acumen, for example, has developed a field guide for collection and use of social performance data called the "Lean Data Field Guide" which includes tools for efficient but rigorous data collection in a way that also benefits the company and customers. They also created a detailed report called "Innovations in Impact Measurement" that includes lessons learned from their use of mobile technology for social impact measurement. Other useful and relevant information on impact metrics and methods is available on the Global Impact Investing Network website at https://thegiin.org/tools/. The IRIS catalogue of metrics provide standardized guidance about the types of metrics to use and a common language to improve comparability across investments.

SOCIAL IMPACT INDICATORS

ENTERPRISE LEVEL	**JOBS**	
	QUALITY OF JOBS CREATED	
		Full-time/ part-time
		Permanent/ temporary
		Management level
		Area within the value chain
		Geographic location
	INCOME NON-MANAGEMENT STAFF full-time/part-time or permanent/annual & temporary/seasonal	
		Income management staff
		Women-owned

EMPLOYEE/ ENTREPRENEURS LEVEL	**LIVELIHOODS**
	ACCESS TO AND USE OF FINANCIAL SERVICES
	ACCESS TO AND USE OF CREDIT
	TRAINING AND MENTORING
	ACCESS TO AND PARTICIPATION IN NETWORKS
	EMPOWERMENT/AGENCY
	Agency/self-efficacy
	Communications skills
	Status
	Decision-making & control over resources/ assets

CUSTOMER LEVEL	**ADOPTION**	Use
		Economic stability
		Fuel expenditure
		Income through productive use of cookstove
		Time spent on fuel collection
		Time spent on cooking
	STATUS	Status within the family/community
		Safety/ protection
		Fuel collection safety/ protection
		Cooking safety/ protection
	DRUDGERY	Fuel purchase drudgery
		Fuel collection drudgery
		Cooking drudgery

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