Biomass and Liquid Fuel Cookstoves for United Nations High Commissioner for Refugees: Procurement Specifications, Testing Criteria, and Methodologies

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Photo: Controlled Cooking Test, Dadaab, Kenya, 2010. ©Berkeley Air Monitoring Group

Abbreviations

Abbreviation	Meaning
CO	Carbon monoxide
g	Gram
HAP	Household air pollution
HH	Household
IDP	Internally displaced persons
ISO	International Standards Organization
IWA	International Workshop Agreement
kg	Kilograms
L	Liters
mg	Milligram
$PM_{2.5}$	Particulate matter less than 2.5 microns in diameter
ppm	Parts per million
SAFE	Safe Access to Fuel and Energy
SD	Standard deviation
UNHCR	United Nations High Commission for Refugees
WHO	World Health Organization

1. Introduction: Project Background and Objectives

Background

More than 51.2 million people are displaced from their homes due to conflict, war, and disaster. Of these, 16.7 million are refugees living outside their home nation, and 33.3 million are internally displaced people (IDPs) who remain in their own countries but are forced to leave their homes. They leave with few possessions and in fear of their lives. Some find refuge in official camps; others in the homes of distant family or friends.

Most of the food provided by humanitarian agencies such as the World Food Programme and the United Nations High Commissioner for Refugees must be cooked before it can be eaten. Rations typically include dried beans, corn, soy, rice, and/or flour. Unfortunately, the cookstoves and fuel with which to prepare these energy-dense foods are rarely provided.

In the cases where cookstoves are provided in humanitarian settings, the quality varies widely from primitive mud cookstoves to metal and ceramic models, produced by artisans in the vicinity of refugee camps, and finally to prefabricated engineered cookstoves manufactured in developed nations. The majority of these cookstoves burn biomass, which is rarely provided to the displaced populations. Instead, many displaced people, the majority of which are women and children, spend hours each day struggling to collect sufficient firewood from increasingly barren landscapes, exacerbating conflicts with host communities, and putting themselves at risk of attack or injury. In many countries, refugees are legally prohibited from collecting wood outside of the camps and as a result are hesitant to report abuse and violence. Support for other household energy needs, such as heating, lighting, or powering appliances is similarly absent, and this lack of energy negatively affects personal and food security, health, shelter, education, livelihood, biodiversity, and the environment. More efficient and cleaner cookstoves, fuels, and energy technologies can play a significant role in improving quality of life of crisis-affected populations.

Over the past several years, key developments in the clean cooking and humanitarian sectors have paved the way for a more streamlined and effective approach to improving the cooking experience in humanitarian settings. In 2010, the recently formed Global Alliance for Clean Cookstoves (Alliance) outlined a goal of catalyzing 100 million households to adopt clean and efficient cookstoves and fuels by 2020, in order to save lives, improve livelihoods, empower women, and protect the environment. Although the Alliance's primary focus is on creating a thriving global market to support this target, ensuring access to clean and efficient energy for vulnerable populations is a key part of their strategy.

At about the same time, UNHCR's Interagency Safe Access to Fuel and Energy (SAFE) Steering Committee began to raise awareness of the enormous challenges faced by refugees and other crisis-affected communities by using a cross-sectoral approach that focuses on increasing accessibility to fuel and energy for cooking, heating, lighting, and powering. SAFE's strategic objectives are: integrate energy into emergency preparedness and response, develop and implement country-level energy strategies, improve access to household fuels and lighting using appropriate technologies and renewable energy, increase access to energy for schools and health centers, and establish and manage woodlots for fuel provision and environmental protection. On behalf of the SAFE Steering Committee, the Alliance created a platform for sharing information and resources across all of the relevant institutions that support vulnerable populations, which enables consistent, data-driven management of energy issues in humanitarian settings.

Another important building block for improving the cooking experience in humanitarian settings was achieved in 2012. An ISO International Workshop Agreement was unanimously agreed upon by a broad array of household energy experts and stakeholders from 23 countries, as a preliminary step towards the development of formal global quality standards for cookstoves and fuels. The ISO IWA 11:2012 -- Guidelines for evaluating cookstove performance -- provides a framework for rating cookstoves against tiers of performance for a series of performance indicators and offers guidance on testing protocols (see section 3.1 for a technical description of the IWA). The existence of a consensus-based structure for categorizing and comparing cooking technologies and fuels allowed partners to communicate effectively across cultures, contexts, and languages about the relative merits and weaknesses of various solutions. By building on this tool, it is now possible for the humanitarian sector to define and procure a set of cooking energy options that are of a relatively uniform quality but offer diverse features, appropriate to the wide range of populations and settings that are served by these institutions.

Objectives

The United Nations High Commission for Refugees (UNHCR), with the support of the Alliance, is in the process of developing technical specifications for improved cooking technologies to be procured for its humanitarian response operations. These specifications will be used to create a pre-vetted list of high-quality, context-appropriate cooking technologies from which country offices can select for procurement and distribution. The frame agreement will allow UNHCR and its donors to procure improved cookstoves directly from preselected manufacturers and will facilitate a more streamlined and speedy procurement process. It is hoped that the technical specifications will also provide a model for other humanitarian agencies seeking to procure quality cookstoves.

The process for developing this frame agreement can be condensed into six steps:

- Step I: Determine general requirements and preferred technology specifications in a variety of categories;
- Step II: Hire technical expert to review existing literature, conduct key informant interviews and examine field and lab test results in a variety of categories, and refine categories and technology requirements specifications with minimums and maximums, as appropriate;
- Step III: Consult with sector stakeholders (including humanitarian implementers, testing experts, enabling agencies, etc.) on viability of technical specifications.
- Step IV: UNHCR develops and launches tender and submission template using the generic technical specifications as a reference.
- Step V: For all improved cooking technologies that meet the technical criteria in the tender, UNHCR conducts additional field testing to evaluate user acceptance and to validate technical specifications identified by lab results.
- Step VI: UNHCR develops frame agreement with selected manufacturers.

Berkeley Air Monitoring Group, an independent technical consulting firm specialized in the cookstove and household energy sector, is the primary author of this report. Berkeley Air has widespread technical experience measuring cookstove efficiency and emissions, and assessing impacts of technologies and fuels on health, climate, and socioeconomic outcomes in Africa, Latin America, and Asia. This report was commissioned by the Global Alliance for Clean Cookstoves, a public-private partnership hosted by the

UN Foundation to save lives, improve livelihoods, empower women, and protect the environment by creating a thriving global market for clean and efficient household cooking solutions. The Alliance's activities currently engage a strong network of over 1300 public, private, and non-profit partners, including over 15 national governments, and dozens of global strategic partnerships and alliances.

2. Specifications for UNHCR Frame Agreement for Cookstove Procurement

The following technical specifications are recommended to the United Nations High Commission for Refugees (UNHCR) for improved cooking technologies to be procured for its humanitarian response operations, at various stages of response.

Manufacturers of improved cooking technologies that meet these technical specifications will be considered for a two-year frame agreement with UNHCR, with an option for extension. Manufacturers with more than one qualifying cookstove model or cooking accessory are encouraged to submit all relevant products for consideration, with each model requiring a separate application. In order to qualify, manufacturers must propose cookstoves that meet all of the mandatory specifications presented here; superior achievement in one category may not be substituted for insufficient quality in another area. For example, a cookstove that easily meets the Tier 2 threshold for fuel efficiency, but does not meet Tier 1 requirements for indoor air emissions would not be recommended for the frame agreement. Manufacturers are also encouraged to meet the additional recommended specifications wherever feasible.

A frame agreement does not guarantee purchase. Instead, the frame agreement serves as a pre-vetted list of high-quality, context-appropriate cooking technologies from which country offices can select for procurement and distribution to humanitarian populations. The frame agreement will allow UNHCR to procure improved cookstoves and cooking devices directly from the preselected manufacturers and will allow for a more streamlined and speedy procurement process.

2.1. Overview of Procurement Specifications

Cookstoves are used by refugees, IDPs, and other crisis-affected populations primarily to cook food rations and sometimes, secondarily, to boil water, cook animal fodder, or provide heat and light. They are defined as cooking technologies that are not connected to central utilities, such as natural gas or electric grid, and are not designed primarily for developed-country recreational use. They are designed to cook food for a household, in contrast to institutional food preparation, although in humanitarian settings, they may serve particularly large households or groups of families.

Biomass cookstoves are those fueled by wood sticks, twigs, leaves, roots, or other plant-derived materials such as agricultural byproducts (e.g. rice husks, corn cobs, and crop stalks). Animal dung is also a common biomass fuel in some regions. The biomass fuel may be in raw form or processed into pellets or briquettes. Charcoal cookstoves are not covered by these specifications. Liquid-fuel cookstoves describe those appliances using ethanol, methanol, or biogas. Cookstoves using liquid petroleum gas are already covered elsewhere in the UNHCR procurement system, and the World Health Organization (WHO) recommends against kerosene and coal cookstoves.

As the cookstoves are used daily in the midst of family life, they must be durable, safe and reduce negative health effects from smoke exposure. Cookstoves are often moved, so they must be portable, ergonomic, and rugged. Further, the manufacturer must demonstrate that provisions can be made for consistent quality, the maintenance and repair of the cookstoves and user training and support on proper operation. Lastly, the cookstoves must be fuel efficient in order to reduce the burden of collecting or purchasing fuel for the users, ease the competition among communities for scarce fuel resources, and protect the natural environment.

The complete list of specification for both biomass and liquid-fuel cookstove procurement are presented in Table 1, with additional explanatory text provided for each specification category in Section 3.

Table 1. Overview of specifications for biomass and liquid-fuel cookstoves.

<table>
<tr><th rowspan="2">Category</th><th colspan="2">Specifications</th><th rowspan="2">Recommended Documentation</th></tr>
<tr><th>Biomass Cookstoves</th><th>Liquid-Fuel Cookstoves</th></tr>
<tr><td colspan="4">Fuel Efficiency</td></tr>
<tr><td>Mandatory</td>
<td>Meets IWA 11:2012 Tier 2 for fuel efficiency (for comparison, this is equivalent to ~30-50% more fuel efficient than a typical three-stone fire).</td>
<td>Meets IWA 11:2012 Tier 2 for fuel efficiency (for comparison, this is equivalent to ~30-50% more fuel efficient than a typical three-stone fire).</td>
<td>Test results reporting template supported by test report: http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/8-2.docx</td></tr>
<tr><td colspan="4">Safety</td></tr>
<tr><td>Mandatory</td>
<td>Meets IWA 11:2012 Tier 3 for safety; and
Meets following minimum scores on Biomass Cookstove Safety Protocol subcategories:
<table>
<tr><th>Subcategory</th><th>Score</th></tr>
<tr><td>2. Cookstove tipping</td><td>3</td></tr>
<tr><td>3. Containment of fuel</td><td>3</td></tr>
<tr><td>9. Flames surrounding cookpot</td><td>3</td></tr>
<tr><td>10. Flames exiting fuel chamber, canister, or pipes</td><td>4</td></tr>
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</table>
Fuel specifications for stove compatibility are provided.</td>
<td>Test results reporting template supported by test report: http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/8-2.docx
Biomass Stove Safety Test Report: http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/407-1.pdf</td></tr>
</table>

Category	Specifications		Recommended Documentation
	Biomass Cookstoves	Liquid-Fuel Cookstoves	
Air quality			
Mandatory	• Meets IWA 11:2012 Tier 1 for indoor emissions (for comparison, this is equivalent to emitting ~0-58% less $PM_{2.5}$ and ~0-36% less CO per minute than a typical three-stone fire).	• Meets IWA 11:2012 Tier 4 for indoor emissions (for comparison, this is equivalent to emitting 95-100% less $PM_{2.5}$ and 57-100% less CO per minute than a typical three-stone fire). • Per WHO Guidelines for Indoor Air Quality: Household Fuel Combustion, kerosene not recommended due to potential health impacts.	• Test results reporting template supported by test report: http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/8-2.docx
Durability			
Mandatory	• The manufacturer must provide a warranty against defects of at least 1 year.	• The manufacturer must provide a warranty against defects of at least 1 year.	• Manufacturer documentation providing warranty details.
Recommended	• Meets an overall maximum risk factor score of 20 on the Cookstove Durability Protocol, with scores of 4 or less on each subcategory. • Service/maintenance plan	• Meets an overall maximum risk factor score of 20 on the Cookstove Durability Protocol, with scores of 4 or less on each subcategory. • Service/maintenance plan	• Cookstove Durability Test Report: http://cleancookstoves.org/binary-data/DOCUMENT/file/000/000/89-1.pdf • Manufacturer documentation providing details of service plan.

Category	Specifications Biomass Cookstoves	 Liquid-Fuel Cookstoves	Recommended Documentation
	User-acceptability		
Mandatory	• Delivers at least 0.5 KW of cooking energy at high power. • Firepower can be easily, reliably, and safely changed. • For batch-fed cookstoves, firepower can be controlled to be operated at half of their maximum firepower. • Can accommodate standard UNHCR pots (5L 22-24cm internal diameter, and 7L 25-28cm internal diameter), and compatibility with larger pot sizes and pans/griddles for cooking flat breads desirable. • Has at least two sturdy handles with no sharp edges that achieve a minimum temperature rating of “3” on the biomass safety protocol. • Weighs less than 15kg.	• Delivers at least 0.5 KW of cooking energy at high power. • Can be operated at half of its high firepower. • Firepower can be easily, reliably, and safely changed. • Can accommodate standard UNHCR pots (5L 22-24cm internal diameter, and 7L 25-28cm internal diameter), and compatibility with larger pot sizes and pans/griddles for cooking flat breads desirable. • Has at least two sturdy handles with no sharp edges that achieve a minimum rating of “3” on the biomass safety protocol. • Weighs less than 15kg.	• Laboratory test report results. • Physical specifications sheet including mass and dimensions of stove.
Recommended	• User-acceptability testing has been conducted. • The stove does not require a fuel size or other fuel characteristics that necessitate overly burdensome fuel processing.	• User-acceptability testing has been conducted.	• Manufacturer submitted user acceptability report(s).

Category	Specifications		Recommended Documentation
	Biomass Cookstoves	Liquid-Fuel Cookstoves	
Training			
Mandatory	• Accompanied by pictorial usage and safety instructions for end-user as well as a training curriculum and materials in English for implementing partners.	• Accompanied by pictorial usage and safety instructions (including safe fuel handling and storage methods) for end-user as well as a training curriculum and materials in English for implementing partners.	• Manufacturer submitted training and safety materials.
Production and storage capacity			
Mandatory	• Manufacturer can produce a minimum of 3000 cookstoves per month and maintain an inventory of 3,000. • Manufacturer has a written quality assurance and control plan that provides routine checks for consistency in physical specification of cookstoves produced.	• Manufacturer can produce a minimum of 3000 cookstoves per month and maintain an inventory of 3,000. • Manufacturer has a written quality assurance and control plan that provides checks for consistency in physical specification of cookstoves produced.	• Manufacturer submitted documentation verifying production and storage capacity.

2.2. Verification of specifications

Cookstove performance testing should be conducted by an independent organization with no financial interest in the outcome, and that has demonstrated experience using the protocols required for testing against IWA Tiers. (See additional guidance in Annex 6.3.) For all other specifications, supporting documentation and evidence should be provided by the manufacturer or distributor.

3. Explanation of Indicators and Metrics

Where applicable, guidance from IWA 11:2012 was used as framework for establishing performance thresholds for UNHCR's procurement specifications. IWA 11:2012 was agreed upon by a range of household energy experts and stakeholders, and includes performance guidance on fuel efficiency, total emissions, indoor emissions, and safety. The agreement outlines "Tiers of Performance" that specify performance ranges based on laboratory testing. The tier ranges span from performance that is equivalent to traditional three-stone-fires (Tier 0) to aspirational performance goals (Tier 4), with Tiers 1-3 representing incremental progress. The protocols used to determine performance against Tiers are the Water Boiling Test (4.2.3) for emissions and efficiency, the Biomass Cookstove Safety Protocol (1.1) for safety, and the Cookstove Durability Protocol (1.0) for durability.

The specifications provided here have been informed by feedback from a range of stakeholders working in the household energy and humanitarian relief sectors (Annex 6.3), with consideration for the performance of cooking technologies that could be practically used in refugee and humanitarian settings. Fuel efficiency, indoor emissions, and safety were the three main performance categories for which the IWA 11:2012 was applied. Indoor emissions were included in the specifications as they are most closely linked with health outcomes, whereas total emissions are more closely related to environmental benefits.

It is also important to note that in cases where guidance from the IWA is either not applicable (e.g. warranties) or extra guidance is needed (e.g. storage of liquid fuels) we have provided additional justification. For more details on IWA 11:2012, see: http://cleancookstoves.org/about/news/01-01-1990-iwa-tiers-of-performance.html.

3.1. Fuel Efficiency

Fuel efficiency is consistently identified as a highly desirable cookstove trait by users and humanitarian professionals alike, including the stakeholders specifically consulted in this process. A minimum performance at the Tier 2 level implies that qualifying cookstoves would be at least 30 to 50% more fuel efficient than a three stone fire (see Table 2). Importantly, the fuel savings achieved in homes will be affected by several factors, most critically the extent to which the new cookstove displaces the traditional cooking technology. A cookstove that uses 75% less wood than the three stone fire during the Water Boiling Test, for example, may be infrequently used if it is difficult to operate or not compatible with local cooking demands, thereby resulting in negligible fuel savings. Thus, care should be taken to consider how well the new cookstove will be integrated into households based on how readily and easily it can be used to prepare the local dishes and the overall potential for user-acceptance (see section 3.5 for more guidance on this topic).

Table 2. IWA 11:2012 Tiers of performance for fuel efficiency.

Efficiency/fuel use tiers			
	High power thermal efficiency (%)	Low power specific consumption (MJ/min/L)	Increased fuel efficiency⁺
Tier 0	<15	>0.050	0%
Tier 1	≥15	≤0.050	>0-31%
Tier 2	≥25	≤0.039	31-51%
Tier 3	≥35	≤0.028	51-66%
Tier 4	≥45	≤0.017	66-76%*

⁺Averaged from high and low power and relative to a typical three-stone-fire. Baseline stove types vary by region, which will impact potential fuel savings.
*Assuming maximum performance of 55% thermal efficiency and 0.01 MJ/min/L specific consumption.
For plancha or griddle style stoves designed for cooking flatbreads, efficiency testing should be conducted using specialized pots which cover the entire cooking surface area.

3.2. Safety

Cookstove safety is a major concern in camp settings. Reducing fire risk is critical, while lowering incidents of cuts, burns, and other injuries is also important. The Biomass Cookstove Safety Protocol provides assessments for these hazards, evaluating risk associated with sharp edges, stability, surface temperatures, obstructions, fuel containment within cookstove, and containment of cooking flames. Quantitative tests to measure scores for these categories provide scores from 1 (poor) to 4 (best), which are then weighted and summed to provide an overall score out of 100 . An overall safety Tier 3 rating was assigned to both biomass and liquid fuel cookstoves, which ensures strong safety performance while also allowing for a range of potentially qualifying cookstoves. Given the strong concerns over fire safety, cookstoves must also score a minimum of 3 on the specific subcategories of cookstove tipping, containment of fuel, flames surrounding cookpot, flames surrounding cookpot, as well as score 4 for flames exciting fuel chamber, canister, or pipes (only a score of 1 or 4 is possible for this category).

Table 3. IWA 11:2012 Tiers of performance for safety.

Safety	
	Scale of 0-100
Tier 0	<45
Tier 1	≥45
Tier 2	≥75
Tier 3	≥88
Tier 4	≥95

For liquid fuel stoves, the manufacturer must provide documentation that specifies fuel compatibility with the associated cookstove. While the fuel supply system is not the manufacturer's responsibility, and therefore mandatory specifications are not provided for this component, additional recommendations are provided here for mitigating the hazards associated with use of liquid fuels, notably fire and accidental ingestion. All fuel storage vessels should be clearly labelled to identify the fuel and its associated hazards. Fuel storage should be designed to minimize the risk of fuel spilling, leaking, or igniting. For ethanol and any other fuel sources that can be ingested, fuel should be denatured and stored in containers that do not resemble common beverage packaging.

3.3. Air Quality

Given the imperatives for short-term survival, safety, and security common in refugee camps and other humanitarian settings, the long-term health outcomes associated with cookstove pollution, while important, are generally considered a secondary priority, a position echoed by the stakeholders specifically interviewed for this project. A minimum performance at the Tier 1 level implies that qualifying biomass cookstoves would have PM and CO emission rates up to 58% and 36% lower than a traditional three stone fire, respectively (see Table 2). Theoretically, cookstoves with indoor emissions rates nearing that of the three-stone fire could qualify under this framework, as the tier boundary separates Tiers 0 and 1, implying the possibility of almost no reductions for cookstoves on the lower end of Tier 1 performance. While even the best performing cookstoves for Tier 1 indoor emissions may only reduce exposure to air pollutants enough to provide minimal health benefits, they do represent an improvement compared to the baseline scenario and can create a more comfortable cooking environment.

For liquid-fueled cookstoves, the threshold was set at Tier 4, as these cookstoves can readily achieve this performance level. Cookstoves at this performance level provide a clean option for situations where air quality and long-term health are considered priorities. Similar to reductions in fuel use, the potential air quality improvements will be affected by the extent to which the traditional cookstoves are displaced, with the largest benefits being realized in homes where the new cookstove is being used exclusively.

Finally, per the recent World Health Organization Guidelines for Indoor Air Quality on Household Fuel Combustion, kerosene is not recommended as a household energy source. The WHO's recommendation on kerosene was based on research which indicated that use of kerosene may pose significant health risks, even in comparison to biomass (WHO, 2014).

Table 4. IWA 11:2012 Tiers of performance for indoor emissions.

Indoor emissions tiers				
	Indoor emissions $PM_{2.5}$ (mg/min)	Emissions Reduction*	Indoor emissions CO (g/min)	Emissions Reduction*
Tier 0	>40	0%	>0.97	0
Tier 1	≤40	>0-58%	≤0.97	>0-36%
Tier 2	≤17	58-80%	≤0.62	36-49%
Tier 3	≤8	80-95%	≤0.49	49-57%
Tier 4	≤2	95-100%	≤0.42	57-100%

*Relative to a typical three-stone-fire. Baseline stove types vary by region, which will impact potential air quality improvements.

3.4. Durability

Having cookstoves that continue to function properly through multiple years of use is important to all the stakeholders in humanitarian settings. As a result, manufacturers are required to stand behind the quality of their products by providing a warranty guaranteeing the cookstove's basic condition and operation. The warranty must cover manufacturing defects, as well as ensure that components necessary for the safe and normal operation of the cookstove will be fully functional for a minimum of one year under typical operating conditions. A service plan is also recommended to support the warranty, with special consideration given to how the service plan can be implemented in humanitarian settings.

While predicting cookstove lifetime is difficult, the Cookstove Durability Test protocol can provide an indication of a given stove's susceptibilities to degradation or failure and is recommended for all applicants.[1] A maximum overall risk factor score of 20 will provide additional assurance that a stove is well constructed. Further, maximum risk factor scores of 4 for each test subcategory (extended run, external impact, internal impact, corrosion, coating adhesion, quenching, and material temperature), will help guard against premature failure of key stove components. Stoves that achieve these results will receive special consideration in the evaluation process.

3.5. User-Acceptability

User-acceptance is more likely to be achieved if a given cookstove can readily cook the local cuisine with straightforward convenient operation. Depending on the cooking practices common to the local population, the set of cookstoves needed will be diverse. As such, cookstoves should be selected based on a detailed overview of what types of cooking they can readily accommodate, including frying, large batches of starches, as well as specific types of ethnic foods such as naan, injera, tortillas, etc. The factors listed below -- cookstove power, pot-size compatibility, portability, and fuel processing requirements -- have been determined, in various field studies, to be key determinants of user-acceptance and therefore, should also be considered in any cookstove selection process. It is also recommended that implementers reference the SAFE project database once they have compiled a shortlist of cookstove technologies. The database provides cookstove technology specific information and can give current implementers a good idea of past implementers experience with the technology in question. For more details see: http://www.safefuelandenergy.org/where-we-work/search-projects.cfm or email SAFE SC for additional information at: info@safefuelandenergy.org

3.5.1. Cookstove power

Cooking power demands vary by dish, cuisine, and the amount of food to be prepared. Cooking power is defined as how much useful energy is delivered to the cooking vessel per unit time. For example, if a cookstove has 25% thermal efficiency and has a firepower of 4 KW (consumes fuel energy at up to a rate of 4 kilojoules per second), then its maximum cooking power is 0.25 X 4kW = 1 KW delivered to the pot. Typically, higher cooking powers are desirable because they permit a wider range of foods types and quantities to be prepared, as well as cooking food more quickly. Cookstoves that do not have enough cooking power to prepare the staple dishes for given region or camp are unlikely to be used as a primary cookstove. The following guide provides the approximate minimum cooking powers required to meet various typical cooking demands. At a minimum, cookstoves should be able to deliver more than 0.5 kW of energy to the cooking vessel and higher cooking powers are generally desirable. Cookstoves which provide less than 0.5 kW of cooking power are generally small and designed for specific tasks such as preparing tea. There are many natural and forced draft cookstoves which can provide the medium or high cooking power levels indicated in Table 5, many of which come in different sizes to account for differing cooking demands. Changing firepower should be easy, safe, and reliable. Specifically, changing

[1] Durability testing is not required for all applicants due to current limitations in the availability of qualified testing centers with capacity to carry out the protocol.

firepower should not involve restarting the cookstove, dumping out fuel or conducting tasks that cause increased risk of risk of tipping, burning or other hazards.

Table 5. Approximate minimum cooking power to meet various cooking demands.

Maximum cooking power	Common Tasks
Low: <0.5 KW-delivered	Preparing tea, simmering tasks
Medium: 0.5-1 KW-delivered	Frying vegetables or meats, preparing stews, or boiling smaller (<5kg) batches of starches such as rice, maize meal, or matooke.
High: >1 KW-delivered	Boiling large batches (>5kg) of starches such as rice, maize meal, or matooke. Also good for boiling water for drinking and sanitation.

Notes: Griddle or plancha style cookstoves used for primarily cooking breads such as injera or tortillas should not be evaluated with this criteria as the cooking power for these foods is difficult to measure with the WBT 4.2.3. A draft protocol for testing griddle/plancha cookstoves is in development, but quantitative guidance on cooking power is not currently feasible.

In addition the ability to deliver enough power to cook staple foods, cookstoves that can readily use a range of cooking powers are generally desirable, especially in places where starchy foods are staples. Cooking power is not a metric that can be measured at low power using the Water Boiling Test (4.2.3), and therefore is not possible to use as reference specification here. However, firepower (the amount of fuel energy consumed by the cookstove per unit time) is reported for the high power (boiling) and low power (simmering) phases of the test, and can be used as a reasonable proxy for the ability of a cookstove to provide a flexible range of cooking powers. Liquid-fueled cookstoves and batch-fed cookstoves, which are loaded with batches of fuel (e.g. pellets) before cooking commences, and any other cookstoves that are not regulated by the rate at which the user directly feeds fuel into them should have firepower ratios of at least 2:1 for the boiling and simmering phases of the WBT. It is assumed that cookstoves for which firepower is controlled by adding or removing sticks can be operated across a broad range of cooking powers.

3.5.2. Cooking vessels

At a minimum, cookstoves should be able to accommodate standard UNHCR pots distributed at refugee camps. Standard pots hold 5 or 7 liters of water, with inner diameters 22-24cm and 24-28cm, respectively. Therefore, pot rests should be able to support vessels with diameters ranging from ≤22cm to ≥28cm or more. Cookstoves with built-in pot skirts should have skirts with a minimum diameter of 29 cm. Compatibility with pans, griddles, or other cooking vessels used for preparing flat breads is also desirable, especially for cookstoves to be used in areas where these are staple foods.

3.5.3.Portability (handles and weight)

Given the frequent movement of cookstoves within camps and households, cookstoves should be easily transferable, with minimal risk, damage to the cookstove, and/or discomfort or injury to the person moving them. Grasping and lifting the cookstove should not result in the handles bending, breaking, cracking, slipping, loosening, or malfunctioning in any manner, even with the addition of a water filled 7L pot (~8kg). Handles should also not pose a burn risk, and must score a minimum of 3 on the biomass safety protocol (<26°C+ambient temperature for metallic handles and <38°C+ambient temperature for non-metallic handles).

Cookstove weight should not be burdensome or pose risks due to daily lifting and/or carrying. ISO standard 11228-1:2003(E), which provides guidance on ergonomics, recommends that an object carried for a long distance (20 m) at a carrying frequency of once per minute should have mass no more than 15 kg (ISO, 2003). While the frequency of carrying is far higher than that expected for a cookstove, the ISO guideline provides a conservative threshold as specified here.

Conversely, some users may also desire cookstoves to have enough mass to feel sturdy. Anecdotal evidence suggests that some users prefer cookstoves that have enough mass to be perceived as substantial. While the tipping test of the Biomass Cookstove Safety Protocol (see section 3.2) should account for a cookstoves ability to resist tipping, the feeling of substantive mass may provide some users with increased confidence in a given cookstove's sturdiness. No universal minimum cookstove mass specification can be identified, but it is nonetheless recommended that consideration be given to users' perceptions of cookstove mass/sturdiness, especially in regions where starch dishes that require rigorous stirring are frequently prepared.

3.5.4.Fuel processing

The time and effort required for users to process fuel can be a deterrent to the adoption and on-going usage of new cookstoves. Some cookstoves that require fuelwood to be cut into regular pieces substantially smaller than those used for traditional cookstoves, for example, have been shown to have minimal impact on displacing the traditional technologies (Namagembe et al., 2015; Pillarisetti et al., 2014). It is therefore recommended that fuel preparation requirements for qualifying cookstoves be comparable to those needed by the traditional or baseline cookstoves. Alternatively, preprocessed fuel should be made available to the users.

3.6. Training

Correct use and operation of the cooking technologies is important for maximizing their benefits and ensuring user safety. Research conducted by USAID revealed that cookstove program implementers have sometimes underestimated the need for end-user training, with detrimental impacts on their programs' effectiveness. Training programs which address key topics on operation and safety should accompany the cooking technology.

3.6.1. Core training topics

- Cookstove and fuel use safety, including operation and storage. For liquid fuel stoves, the training materials and program should include practices for the safe handling and storage of the fuel.
- Guidance to new cookstove users on how to use their cookstove effectively (i.e., how to adapt cooking behaviors, etc.).
- Guidance on how to maintain, and, where possible, repair the cookstove.
- Explanation of the potential benefits of using the new cookstove.
- Guidance on what not to do with the new cookstove (i.e., alter cookstove dimensions, bend handles etc.)

- Explanation of how to use supplemental cooking technologies, if relevant (e.g. pot skirts or retained heat cookers).

3.6.2. Other possible topics

- Water and sanitation training to promote the idea of healthy kitchens
- Explaining the potential health impacts of indoor air pollution, especially on children, and present options to decrease risk (i.e., remove infants/young children from the cooking area, cook outside, etc.) (USAID, 2010).
- Promote environmental conservation by building awareness of the important ecosystem roles that trees play and connection between fuels efficiency and saving trees.
- Energy saving practices
- Guidance on how to adapt behavior for the new cookstove (i.e. soaking beans).

3.7. Production and Storage

In emergency situations, it is crucial that the cookstoves can be deployed rapidly in mass quantities, with relatively short notice. Therefore, the manufacturer can produce a minimum of 3000 cookstoves per month and maintain an inventory of 5,000.

From a cost perspective, it is also desirable to procure cookstoves that are efficiently packed, minimizing shipping and storage costs. This efficiency is often achieved by "flat-packing" the cookstove's individual components, with the intent that the appliance can be reassembled at its final destination. The implications of the flat-packing approach should be carefully considered, however, as they will not be suitable for every situation. Local cookstove assembly and finishing at or near the point of dissemination can be attractive not only as a cost-saving strategy but also as a skill-building or revenue-generating activity for vulnerable populations. Nonetheless, this approach has certain requirements for space, tools, and capabilities. If these are not met, the resulting cookstoves may be lower quality or completely dysfunctional.

4. Guidance on Cookstove Selection

4.1. Strengths and Limitations of Illustrative Qualifying Cookstove Types

Only certain cookstove models will be appropriate for any specific community and context. Table 6 describes regional and cost considerations, the advantages and disadvantages, and expected field performance of artisanal and semi-industrially produced cookstoves, prefabricated natural and forced draft cookstoves, and liquid gas cookstoves. In addition to the cookstove selection factors listed in Table 6, the user-acceptance factors discussed in section 3.5 should also be considered in selecting the most appropriate cookstove.

Table 6. Regional and cost considerations and advantages and disadvantages of cookstove models.

Cookstove Type	Cost considerations	Advantages	Disadvantages	Regional considerations	Example Field Performance
Artisanal and semi-industrially produced cookstoves 	**1-20 USD**	• Can be locally sourced • Often compatible with multiple biomass fuels (wood, crop residues). • Some have portable and fixed versions. • Often compatible with local cookstove use practices and cooking demands. • Replacement cookstoves or parts can be locally sourced.	• Requires regular maintenance, not to the same degree as a mud cookstove, but cracks need to be attended to regularly (with a ceramic cookstove) • Materials and construction can be variable/low quality. • Reductions in emissions and fuel efficiency may be modest. • Depending on the availability of local human resources, may not be able to do mass production in times of emergency	• Locations where security, funding, or other constraints prevent the introduction of more cookstoves • Sites where production can be centralized and facilities are large enough to store drying cookstoves. • Regions where there is a need to heat living spaces.	**East Africa example** • Simple ceramic lined portable wood cookstove. • Fuel consumption reduction of 15% fuel during Kitchen Performance Tests. • (Wanjohi, 2006)

Cookstove Type	Cost considerations	Advantages	Disadvantages	Regional considerations	Example Field Performance
Prefabricated natural draft cookstove  	**25-50 USD**	• Most models are lightweight • Most models are portable • Some models can be flat-packed (lower shipping costs, more options for storage, etc.) • In general, they heat quickly • Relatively durable • Can burn wood and charcoal with the proper grate (applies to some models) • Often viewed as attractive by the user • Some come with manufacturer warrantees • Rapid production is easier	• For cookstoves that come as kits, assembly still requires time, money, and training • Single-walled metal cookstoves can corrode quickly if not cared for properly • Risk of burns if the cookstove is not insulated to protect against the exterior metal heating up • Some models may require more fuel preparation • Some models may require changes in end-user behavior • Some may not be compatible with local cookstove use practices and cooking demands.	• Relatively secure areas where transport of materials is not a significant concern • Areas where import duties/restrictions are not insurmountable • Areas where maintenance requirements need to be minimized • Where rapid dissemination of cookstoves is needed, or there is no capacity/desire to establish production facilities • Where target populations are expected to be resident for prolonged periods	**East Africa Example** • Rocket cookstove • Fuel consumption reduction of 42% per meal. • PM and CO reductions of 26 and 41% per meal. • Uncontrolled cooking test. • (Johnson et al., 2011)

Cookstove Type	Cost considerations	Advantages	Disadvantages	Regional considerations	Example Field Performance
Prefabricated forced draft cookstove  	**25-100 USD**	• Many models are lightweight and portable • Generally have high cooking powers • Often viewed as attractive by the user • Some come with manufacturer warrantees	• Single-walled metal cookstoves can corrode quickly if not cared for properly • Risk of burns if the cookstove is not insulated to protect against the exterior metal heating up • Some models may require more fuel preparation • Some models may require changes in end-user behavior (i.e. chopping wood into very small pieces for top-loading) • Some may not be compatible with local cookstove use practices and cooking demands.	• Programs with adequate funding to purchase fully assembled cookstoves • Relatively secure areas where transport of materials is not a significant concern • Areas where import duties/restrictions are not insurmountable • Areas where maintenance requirements need to be minimized • Where rapid dissemination of cookstoves is needed, or there is no capacity/desire to establish production facilities • Where target populations are expected to be resident for prolonged periods	**East Africa Example** • Forced draft cookstove. • Reduced fuel consumption by 57% per meal. • PM2.5 and CO emission rates were 90 and 91% less than those from the TSF. • Uncontrolled cooking test • (Johnson et al., 2014)

Cookstove Type	Cost considerations	Advantages	Disadvantages	Regional considerations	Example Field Performance
Liquid gas cookstoves 	**25-100 USD**	• Decreased risks and save time associated with biomass fuel collection • Ultra low emissions. • Many models are lightweight and highly are portable • Generally have high cooking powers • Often viewed as attractive by the user • Some come with manufacturer warrantees	• Fuel is less accessible (it must be purchased) • There are additional safety risks associated with fuel management • Some models may require changes in end-user behavior • Can require significant maintenance • Have been some cookstoves which have not been able to provide enough cooking power.	• Areas that have access to continuous shipments of the fuel • Areas that have adequate funding to purchase both cookstoves and fuel • Where rapid dissemination of cookstoves is needed, there may not be capacity for production/distribution facilities	**East Africa Example** • Ethanol cookstove • PM2.5 and CO kitchen concentrations were 84 and 76% less than in homes using TSFs, respectively • Indoor air quality study • (Pennise et al., 2009) __________________ **Southern Africa Example** • Ethanol cookstove • PM2.5 and CO kitchen concentrations were 85 and 93% less than in homes using TSFs, respectively. • Indoor air quality study • (Practical Action et al., 2011)

4.2. Additional Guidance on Cookstove Selection

- Clean Cooking Catalog: A Global Guide to Clean Cooking Solutions. Global Alliance for Clean Cookstoves: http://catalog.cleancookstoves.org/
- USAID, & AED. (2010). Fuel-Efficient Cookstove Programs in Humanitarian Settings: An Implementer's Toolkit. http://www.energytoolbox.org/cookstoves/
- http://www.safefuelandenergy.org/resources/index.cfm?r=5

5. Field Performance Assessment (M&E)

The procurement specifications in this document are the product of the sector's cumulative learnings, to date, on how to improve the cooking experience for millions of households at the bottom of the pyramid, and in particular, families who depend on humanitarian assistance for survival. Although this is the best available evidence base, in reality, many of these learnings are only indirectly relevant to the challenge of providing access to more efficient and cleaner household energy in refugee, IDP, or emergency contexts.

To date, very few field evaluations of cooking technologies and fuels have been conducted in humanitarian settings. To be most effective over the long term, the Safe Access to Fuel and Energy (SAFE) humanitarian community is advised to regularly monitor the implementation of improved cookstoves and fuels and evaluate actual outcomes and impacts on vulnerable populations and crisis-effected communities. Field performance testing, which uses many of the same evaluation approaches and methods, can also be an important component of formative research to inform the selection of technologies and fuels for a particular location or program.

To date, the bulk of cookstove performance data has been derived from laboratory testing, which is especially valuable in the initial technology design phase and for narrow performance comparisons. Laboratory test results, however, represent a cookstove's performance under generic optimized conditions, which are usually significantly different from actual conditions in any household, let alone those in humanitarian settings. Several studies have shown that laboratory-based test results are different from real-world performance (Bailis et al., 2007; Beltramo and Levine, 2013; Johnson et al., 2010; Roden et al., 2009), primarily due to differences in fuel type, condition, and preparation; cooking practices and foods; environmental conditions; and cookstove tending habits. Field-based assessments are especially needed for a variety of technologies that have the potential to make substantial impacts through fuel savings and reduced emissions. These technologies, such as forced draft biomass cookstoves and mass manufactured charcoal cookstoves, as well as liquid fuels such as ethanol, have shown high performance during laboratory testing, but have not yet been fully characterized in humanitarian settings to determine their user-acceptability and performance during daily camp operations (Berkeley Air, 2012). It should be noted that gas and liquid cookstove performance is less likely to be affected by user operation compared to biomass cookstoves; however, their effectiveness at impacting fuel and/or air-quality relevant outcomes requires more study.

While the IWA dealt entirely with laboratory performance testing, the subsequent ISO standard development process (in progress at the time of this report) includes a working group focusing on field testing methods. The working group is being tasked with reviewing and summarizing existing methods, providing guidance on method applicability, and developing additional approaches as needed. Specific areas of field testing targeted for ISO guidance include evaluating user needs; performance indicators that address consumer needs (consumers broadly defined as individuals or organizations which use the indictors to inform their decisions related to cookstove technologies); integrating and harmonizing laboratory and field assessments; prioritizing measurements to balance comprehensiveness and feasibility; and working with study participants. While the formal ISO guidance will not be available for another 2-3 years, there will likely be methods, guidance, and recommendations that are produced in parallel or as part of the development process. In the meantime, the following summary derives from Berkeley Air's own experience as well as our ongoing review of peer-reviewed and gray literature. A recommended bibliography is provided in Annex 6.5.

5.1. Field Performance Testing or End-Line Evaluation

Field performance testing can be conducted to inform cookstove selection or program design, and usually focuses primarily on the determinants of user acceptability, as well as fuel efficiency and sometimes emissions. In contrast, evaluations are commonly conducted at the end of the program or once a phase of an ongoing initiative has been completed, with the aim of determining the effectiveness of its activities, outcomes, and ultimately its impacts. In the case of cookstoves, evaluations typically measure cookstove adoption, usage, and performance, but may also examine other secondary outcomes and impacts such as levels of household air pollution, and changes in gender equality, well-being, and/or livelihoods. A selection of field methods and instrumentation commonly used for assessing adoption, fuel efficiency, emissions, safety, and durability are presented below.

There are many metrics and methods available to generate objective robust data on the progress, effectiveness, impact, and sustainability of humanitarian cookstove program activities. Here we presents common metrics and methods used to measure the outcomes/impacts described above in addition to links to available resources and protocols. The selection of the most appropriate indicators, measures and methods should be guided by several factors, including the short and long-term goals for the program -- i.e. what questions need to be answered -- as well as its current stage and scale. For example, early formative research on fuel efficiency could be conducted using a controlled cooking test (CCT), whereas once the cookstoves have been in the homes for a few months a household-based kitchen performance test (KPT) would be more appropriate.

It is essential to have a team with the appropriate capacity and skills to ensure the collection of quality meaningful data. Performance field testing and impact evaluations are typically conducted entirely by outsiders. Commonly, two or more entities are needed to fill all the field testing roles, including but not limited to, a local field team with field monitoring experience, a field supervisor adept at carrying out the study design, and an expert with scientific expertise and sector-specific experience to provide study design and data analysis and reporting.

5.1.1.Adoption and use

Assessing and measuring the adoption and use of any clean cooking intervention (cookstoves and/or clean fuels) will be an essential aspect of all SAFE humanitarian programs. If the intervention is not taken up and, more importantly, if it is not used consistently and correctly by the target population, other desired impacts will not follow. This transition cannot be assumed just because a household has been provided with a cookstove. In humanitarian settings, there have been reports of households using their improved cookstove in tandem with traditional or baseline technologies (usually an open fire), selling it for cash in the local market place, salvaging the metal components for other uses, or ignoring it altogether. Collecting actual usage information is therefore a primary evaluation activity that permits the program to estimate the extent of more downstream effects. For example, the extent to which traditional technologies such as basic charcoal cookstoves or three stone fires are offset by cleaner technologies is fundamentally linked to air quality improvements (Johnson and Chiang, in press).

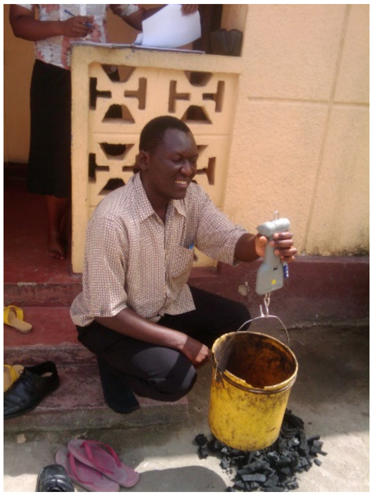
Table 7. Adoption and usage

	Indicators/metrics used	Methods	Useful links
Adoption and Usage	Number households that have taken up (adopted) the intervention? What proportion of overall cooking is being carried out using the new technology (cookstove and/or clean fuel)? What are the patterns and determinants of the intervention use?	Real-time temperature logging sensors such as the Cookstove Use Monitoring System (SUMS) ,SWEETSense or Nexleaf sensor Self-reported or third party structured or unstructured observations of time activity patterns. Qualitative assessment of motivators and barriers to use.	SWEETSense cookstove monitors SUMS Nexleaf sensor 

5.1.2.Fuel efficiency

In humanitarian settings, fuel efficiency is particularly important due to protection concerns when fuel is being collected outside of camp settings or in conflict zones. Fuel savings can also be important contributor to poverty alleviation and reduce unpaid care work burdens, which can have an impact on gender equality and economic empowerment. Fuel efficiency is often a critical feature for users and often a key motivator for upgrading from the three-stone fire or other traditional technology. Fuel savings also has the potential to have far-reaching positive benefits on natural resource, environmental protection, and relations with host communities. Real-world assessment of fuel consumption can be done using either the kitchen performance test (KPT) and/ or the controlled cooking test (CCT) (see comparison below).

Table 8. Fuel consumption

	Indicators/metrics used	Methods	Useful links
Fuel consumption	What effect does the installation of the new technology have on fuel (kg)/ energy (MJ) consumption per cookstove/ per meal/ per person/ per household?	Controlled Cooking Test (CCT): This test controls as many factors as possible such as fuel type, pots, location, ingredients, but is performed in a 'real-life' context and involves a typical cooking task. The results are presented as specific fuel consumption (SFC), which is a measure of dry-wood equivalent (DWE) consumed to cook a given mass of food. Kitchen Performance Test (KPT): The KPT provides a real-world measurement of average fuel consumption for all cookstoves in the study households. Estimates are typically based on the average of three 24-hour periods. Results are usually expressed as kg fuel per standard adult cooked for per day.	CCT Protocol V2.0 KPT Protocol V3.0 

5.1.3. Cookstove emissions

Measuring the pollutants emitted from household cooking technologies is an important indicator of climate impacts as well as a proxy for health effects. Similar to fuel efficiency measurements, field and laboratory assessment of cookstove emissions (carbon dioxide, carbon monoxide, methane, total hydrocarbons, and ultrafine particles) vary greatly. Cookstove emissions can be measured in the field, while a typical end user burns local fuel to cook her normal diet, using a variety of scientific instruments and methods, in either a controlled or uncontrolled study design.

Table 9. Cookstove emissions

	Indicators/metrics used	Methods	Useful links
Cookstove emissions	When used in real world conditions, what rate of health damaging pollutants are given off by this intervention?	Cookstove emissions can be measured in the field using a variety of equipment. However, there are no standardized protocols for conducting in-field emissions measurements. The methods which are used generally involve collecting a fraction of the emissions in the smoke plume during normal daily cooking activities. This approach can provide emission rates estimates which can provide an indication of how well a cookstove is performing relative to both health goals (e.g. IWA 11:2012 Indoor Emissions Tier 4), as well as to the relevant baseline technology.	No standard protocol available 

5.1.4.Cookstove safety

It should not be assumed that an improved cookstove and/or fuel will have the same or increased level of safety compared to the traditional technologies. Unexpected design faults, user unfamiliarity, and significant changes in required cooking and fire tending techniques can all potentially contribute to an increased risk of injury to the cook and her family. Therefore, it is fundamental to a quality cookstove program to conduct an impartial field assessment of the consumer's safety experience with the new cookstove within a few months of dissemination.

Table 10. Cookstove safety

	Indicators/metrics used	Methods	Useful links
Cookstove safety	What is the index score for safety for this cookstove when used by target end users? Does this intervention provide improved levels of safety compared to traditional technologies? Does this intervention raise any safety issues when used by the target end users?	As discussed in Section 3.2, the IWA 11:2012 tiers for cookstove safety is assessed with the Biomass Cookstove Safety Protocol. This involves a variety of standardized tests to assess risks of burns, cuts, cookstove tipping, and other hazards. Scores for each test within the safety protocol are weighted to reflect the relative danger associated with each hazard and summed to provide a single index score for safety. Cookstoves which have been in use for given time periods can be re-evaluated using the same protocol to determine how cookstove safety changes over time for the user. This is currently under development for use in the field.	Biomass Cookstove Safety Protocol

5.1.5.Cookstove durability

Durability is the primary determinant of cookstove lifespan, which is a key economic variable in the cost-benefit analysis for humanitarian agencies planning cookstove disseminations. Even under normal household conditions in many parts of the developing world, cookstoves can be rapidly worn down by the frequent heat cycles and variable biomass feedstock, typical of rural environments. In addition to these stressors, cookstoves in refugee households face additional threats from frequent changes in the cooking location, which cause cooks to drag their cookstoves from inside the home to outside. Damaged cookstoves are likely to fail to deliver the expected performance benefits, and are therefore at higher risk of being permanently abandoned. Thus inferior durability can have far-reaching negative impacts on disseminating to scale.

The current laboratory methods for testing cookstove durability provide a good first line indication of how reliably the cookstove will perform over time and if any of its components are particularly weak or vulnerable to damage. However, as with all of the other parameters presented, field-testing of durability is essential to predict how the cookstove will respond to the particular stresses created by consistent and sustained real-world use. Field methods for testing durability are under development.

5.2. Program Monitoring

An integral part of larger scale and longer-term programs, monitoring is *"a continuing function that uses systematic collection of data on specified indicators to provide management and the main stakeholders of an ongoing development intervention with indications of the extent of progress and achievement of objectives and progress in the use of allocated funds."*[2] It allows for regular feedback about the program's performance and is used to assess if the program activities such as cookstove distribution or establishment of a cookstove training or assembly initiative, are progressing as required to achieve the program's objectives. Monitoring is carried out at intervals during program implementation, beginning at the planning stage, allowing reflection and adaptation as the program matures, to ensure the objectives are attained. The type of monitoring undertaken will depend on several factors including: the information needed; the scale and geographical spread of the program; and the resources and capacity to collect the data. Monitoring is frequently carried out by the implementers themselves, but results should ideally be verified periodically by an impartial third-party. Data should always be sex disaggregated. Illustrative examples of different data sources, indictors to be measured, and resources required are presented in Table 12.

[2] OECD definition http://www.oecd.org/development/peer-reviews/2754804.pdf

Table 11. Examples of the types of data sources, indicators, and required resources.

	Indicators/metrics to assess activities and outputs completed	Source of data	Methods used	Capacity required
Project monitoring	Number of units (cookstoves/clean fuel re-fills) disseminated during reporting period. Number of cookstove models tested, % meeting minimum performance thresholds. Number of cookstove advocates and/or users trained. Number of damaged cookstoves identified and/or repaired. Number of cooking-related fires. Number & duration of fuel collecting trips Perceived changes in biomass cover	Dissemination records Testing center records Training records Camp safety records Repair facility records Local biomass census Key informant interviews	Process used to capture data should be simple and usable to promote compliance. Consider using incentives and engage local managers to encourage long-term co-operation. Data for simple indicators can be captured using Smartphones and other technology, as appropriate and uploaded to a central database.	IT support to design, establish and maintain a centralized database. Project management able to identify and define key indicators. Network of compliant and able stakeholders along the value chain. Data analysis to monitor data entry, analysis and report on data.

6. Annexes

6.1. Cookstove Performance: Guidance and standard documents

Colorado State University, 2014. Cookstove Durability Protocol (1.0). http://cleancookstoves.org/technology-and-fuels/testing/protocols.html.

ISO, 2012. IWA 11:2012: Guidelines for evaluating cookstove performance. http://www.iso.org/iso/catalogue_detail?csnumber=61975

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Pennise, D., Brant, S., Mahu Agbeve, S., Quaye, W., Mengesha, F., Tadele, W., Wofchuck, T., 2009. The Impact of Improved Cookstoves on Indoor Air Quality in Ghana and Ethiopia. Berkeley Air Monitoring Group, EnterpriseWorks Ghana, Gaia Association Ethiopia.

Pillarisetti, A., Vaswani, M., Jack, D., Balakrishnan, K., Bates, M.N., Arora, N.K., Smith, K.R., 2014. Patterns of Stove Usage after Introduction of an Advanced Cookstove: The Long-Term Application of Household Sensors. Environ. Sci. Technol. doi:10.1021/es504624c

Practical Action, Berkeley Air Monitoring Group, University of Liverpool, 2011. Ethanol as a Household Fuel in Madagascar: Health Benefits, Economic Assessment and Review of African Lessons for Scaling Up. The World Bank.

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6.3. Guidance on Cookstove Performance Testing for Tender Applicants

Entities wishing to participate in this procurement opportunity will need to submit cookstove performance testing results from independent testing facilities with demonstrated experience using the protocols required for testing cookstoves against IWA Tiers. Due to limited availability of cookstove testing services, lead times for receiving test results may vary, and applicants are advised to initiate testing as soon as possible during the tender period.

The Global Alliance provides guidance on performance testing including protocols and the most comprehensive list of cookstove testing centers.

6.4. Stakeholder Engagement and Rapid Landscape Assessment

The technical specifications presented in this report are grounded in a strong foundation of sector knowledge shared by Berkeley Air Monitoring Group and the Global Alliance for Clean Cookstoves. Berkeley Air has conducted over 30 technical assessments in some 20 countries since its founding in 2008, whereas the Alliance engages regularly with its network of over 1000 global partners to catalyze a thriving market for clean and efficient cooking solutions. In addition, the technical team interviewed a sampling of stakeholders from the humanitarian sector (see section 6.3.1) to collect targeted input on the objectives and impacts of procurement specifications on humanitarian operations.

6.4.1. Project Interviewees

Organization	Duty Station	Name	Functional Title
UNHCR	Burkina Faso Chad	Olivier Lompo	Environmental Officer
	Rwanada	Madeleine Marara	National Consultant for the SAFE project implementation
	Bangladesh	Farheen Khan	Assistant External Relations Officer
		Sadiqur Rahman	Associate Wash Officer
World Food Program	Rome	Daphne Carliez	SAFE Coordinator
Médecins Sans Frontières Japan	Ethiopia	Oriol Lopez	R&D specialist
International Lifeline Fund	Haiti Uganda Kenya	Vahid Jahangiri	Deputy Director

6.4.2.SWOT Analysis Overview

The initial output from discussions with a sampling of stakeholders (see Annex 6.3.1) as well as a review of pertinent literature was a rapid landscape analysis presented in a SWOT format.

<table>
<tr>
<td>Strength
Purchasing power - attract the best at lowest cost
Standards frameworks available as starting point: ISO (IWA, WHO Air Quality Guidelines)
Procurement system in place
Experience with mass distribution of goods
Learnings from previous cookstove procurement/dissemination efforts in refugee situations</td>
<td>Weakness
Limited flexibility – many locations, fuels, pots, foods need to be accommodated by few cookstoves
With limited budgets, country offices assign low priority to improved cooking technologies, esp. those not manufactured locally.
Program is under time pressure to complete process and have cookstoves ready asap for deployment
Currently no capacity for maintenance/repair of manufactured cookstoves at camps</td>
</tr>
<tr>
<td>Opportunity
Reduce fuel consumption → secondary benefits (save time & relieve drudgery, reduce damage to local ecology, reduce risk of conflicts with host communities, save money, and reduce exposure to GBV)
Reduce safety hazards and injuries to women and children
Improve lives of women
Improve household's health
Manufactured cookstoves could stand up to harsh conditions better / be more durable than locally made cookstoves.
Positively influence commercial markets</td>
<td>Threat
Wasted resources if cookstoves are not used or are ineffective
Harsh conditions will negatively affect many cookstoves
Unintended consequences: household finances - if cookstoves are too nice, refugees will sell them for cash in the market and household safety - e.g. homes can't support chimneys, roof collapse, fire
Host community dynamics
Target audience resistant to behavior change
Specifications too restrictive for producers
Improved cookstoves have unintended consequences
Camp management uncertain about centralized procurement solution</td>
</tr>
</table>

6.5. Field Testing Resources

Recommended bibliography of field testing and evaluation approaches and methods

6.5.1. User-Acceptance, Adoption, and Use

Thomas EA, Barstow CK, Rosa G, Majorin F, Clasen T. Use of remotely reporting electronic sensors for assessing use of water filters and cookstoves in Rwanda. Environ Sci Technol. 2013 Dec 3; 47(23):13602-10. doi: 10.1021/es403412x. Epub 2013 Nov 19

Remotely reporting electronic sensors during a five-month randomized controlled trial of household water filters and improved cookstoves in rural Rwanda. Data was collected intervention use through (i) monthly surveys and direct observations by community health workers and environmental health officers, and (ii) sensor-equipped filters and cookstoves deployed for two weeks in each household.

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This study used two methods to measure the extent and patterns of intervention cookstove adoption and use in 116 households: self-reported use of cookstoves in the previous 24-hours and the application of and cookstove use monitoring sensors (SUMS).

6.5.2. Fuel efficiency

Garland, C., Jagoe, K., Wasirwa, E., Nguyen, R., Roth, C., Patel, A., Shah, N., Derby, E., Mitchell, J., Pennise, D., Johnson, M.A., (In press, corrected proof). Impacts of household energy programs on fuel consumption in Benin, Uganda, and India. Energy for Sustainable Development. doi:10.1016/j.esd.2014.05.005

These U.S. EPA sponsored field studies assessed the fuel consumption impacts of household energy programs in Benin, Uganda, and Gujarat, India. Daily fuel consumption estimates of traditional and intervention technologies were made KPT protocol to determine the potential fuel savings associated with the respective programs.

Adkins, E., Tyler, E., Wang, J., Siriri, D., Modi, V. Field testing and survey evaluation of household biomass cookstoves in rural sub-Saharan Africa. Energy for Sustainable Development 14 (2010) 172-185 doi:10.1016/j.esd.2010.07.003

In 2010 a team from Colombia University and the UNDP Millennium Villages Project used the CCT together with qualitative surveys to evaluate the performance and perceived usability of intervention cookstoves compared to three-stone fires in rural Uganda and Tanzania.

6.5.3. Cookstove emissions

Johnson, M., Lam, N., Pennise, D., Charron, D., Bond, T., Modi, V., Ndemere, J.A., 2011. In-home emissions of greenhouse gas pollutants from traditional and rocket biomass cookstoves in Uganda. United States Agency for International Development, Washington D.C.

Three stone fires and rocket wood cookstoves were assessed in homes in rural Uganda to determine the new cookstove's impact on health damaging pollutants and greenhouse gas emissions. Cookstoves were tested during uncontrolled meal events, for which the authors reported emission factors of particulate matter, carbon monoxide, methane, hydrocarbons, black carbon, and organic carbon.

Roden, C.A., Bond, T.C., Conway, S., Pinel, A.B.O., 2006. Emission Factors and Real-Time Optical Properties of Particles Emitted from Traditional Wood Burning Cookstoves. Environ. Sci. Technol. 40, 6750–6757. doi:10.1021/es052080i

This research study focused on the climate impacts of the aerosol emissions from traditional and improved cookstoves in Honduras. The authors report emission factors for particulate matter, carbon monoxide, as well as metrics specifically related to the scattering and absorption of light. Emission measurements were made during uncontrolled cooking events in homes.

6.5.4. Cookstove safety

Practical Action Consulting (2011). Component A. Ethanol as a Household Fuel in Madagascar: Health Benefits, Economic Assessment and Review of African Lessons for Scaling-Up. February 2011. Full report

The relative durability of two biomass cookstoves and one ethanol fueled cookstove was assessed as part of a 12-month intervention project. Data was collected on the frequency and severity of burns in women and children.

6.5.5. Cookstove durability

Practical Action Consulting (2011). Component A. Ethanol as a Household Fuel in Madagascar: Health Benefits, Economic Assessment and Review of African Lessons for Scaling-Up. February 2011. Full report

The relative durability of two biomass cookstoves and one ethanol fueled cookstove was assessed as part of a 12-month intervention project. Data was collected on broken cookstove components as well as repair options and history.

Bensh, G., Grimm, M., Peter, K., Peters, J., and Tasciotti, L. Impact Evaluation of Improved Cookstove Use in Burkina Faso – FAFASO. March 2013. Full Report

Cookstove durability was assessed using retrospective questions.