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Lessons learned from a comparison study of charcoal stoves for Haiti

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ABSTRACT

Biomass is the predominant cooking fuel in Haiti, where it creates burdens on both the environment and the Haitian people. Following the 2010 earthquake in Port-au-Prince, the need for fuel-efficient cookstoves was acute. Although several organizations were quite interested in dissemination of fuel-efficient stoves in the relief effort, there was little knowledge about the performance and usability of the proposed stoves. To help fill the knowledge gap, stove researchers from Lawrence Berkeley National Laboratory evaluated and compared the performance of several cookstoves intended for dissemination in Haiti. This paper discusses the decisions made throughout the course of that work, from project identification and approach through the dissemination of results. It identifies the challenges faced and how they were addressed, while briefly presenting the data from stove performance evaluated using Water Boiling and Controlled Cooking Tests. It also highlights the importance and benefits of evaluating technologies such as cookstoves prior to dissemination, even in urgent disaster relief situations.

Introduction and background

Most of the ten million people of Haiti use solid fuels, primarily wood and charcoal, for cooking and heating, with the combustion of biomass equaling an estimated 70% of Haiti's annual energy use [1]. Cooking with solid fuels has vast global consequences as approximately 3 billion people worldwide cook with such fuels [2]. Exposure to emissions from these fires causes an estimated 4.3 million premature deaths annually, primarily of female cooks and children who tend to be more often around the cooking fires [3]. Besides such major human health concerns, biomass cooking contributes to environmental damages such as deforestation and global climate change. Charcoal is an especially wood-intensive fuel as wood is typically used not only as the base material for the charcoal but also is burned to produce the heat necessary to convert wood into charcoal. The unsustainable harvesting of wood and production of charcoal over several years has contributed to widespread deforestation in Haiti; in 1923, 60% of Haiti was forested, but by 2009 only 2% of the forests remained [1,3,4,5]. Charcoal for cooking also imposes a large economic burden on Haitians with families spending a significant portion of their income on cooking fuel. For example, in Port-au-Prince, a marmite (a local definition of the amount of charcoal needed to cook roughly half a day's worth of food) costs approximately 0.50 USD in the retail market, while the gross national income per capita is only about 760 USD [6].

A devastating earthquake rendered approximately 1.5 million Haitians homeless in January 2010 [7]. Owing to the significant economic burden on the survivors of procuring cooking fuel, many organizations, such as USAID, the Women's Refugee Committee, and the World Food Programme, called for the deployment of fuel-efficient cookstoves as an essential part of the relief efforts in Haiti [1,8].

Identification of project needs

Lawrence Berkeley National Lab (LBNL) had begun working with cookstoves in 2004, focusing on reducing the fuel consumption necessary for cooking in Internally Displaced Persons (IDP) camps in the Darfur region of Sudan. Using the science and engineering resources of a national laboratory and feedback and information from organizations and users in Darfur, the LBNL stove lab developed a new stove for the region that greatly reduced the fuel necessary for cooking [9,10]. This process required several iterations of scientifically rigorous design and testing at LBNL and feedback from trials in the Darfuri IDP camps. Even working as quickly as possible, the process from an initial field visit (2005) to the production of the first 1000 stoves of fully mature design (2009) took four years.

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Because of this prior experience developing a stove for a difficult relief situation, a team from LBNL responded to the call for fuel-efficient cookstoves in post-earthquake Haiti by undertaking a fact-finding mission to Haiti in April 2010 to evaluate the current stove use situation and identify what, if any, stove development project LBNL should undertake to assist the Haitian relief efforts. The team discovered extensive interest from non-government organizations (NGOs) in stove dissemination projects and found there were already several stoves under development or available for dissemination in Haiti. To gain more information about Haitian cooking practices and the stoves available in Port-au-Prince, the LBNL team interviewed dozens of local cooks; observed cooking in markets, homes, and IDP camps; and conducted a cook-off in which local cooks simultaneously prepared the same meal on multiple stoves, both traditional and improved. Based on observations from this cook-off and the interviews with Haitian cooks, the team determined that neither the dissemination of the Berkeley-Darfur Stove in its current form, nor its adaptation for Haiti would be the best use of LBNL's time and resources.

However, it was apparent to the team that there was reason to question whether the models of improved stoves intended for distribution in Haiti would actually operate efficiently and meet the needs of Haitian cooks. Cookstove distributors and NGOs had little or no data on the performance of most of the stoves and had neither the time nor the expertise and instrumentation to conduct experiments to determine the most appropriate stoves. This meant that relief organizations were distributing cookstoves without knowledge of their efficiency, effectiveness, or potential impact.

Without this information, there was a strong risk that the cookstoves intended for distribution by NGOs would not produce the desired economic and environmental benefits due to either rejection by the local populace or inability to reduce emissions and fuel consumption. Cookstove adoption is notoriously tricky because cuisine, equipment, and cooking methods tend to be both highly localized and culturally significant; the history of cookstove intervention projects is rife with failure. Perhaps because they appear to be simple or "mundane" technologies [11], it is common to underestimate the difficulty in developing biomass cookstoves that are culturally appropriate and high-performing from the perspectives of both NGOs and local users. As with many technologies, if a cookstove is not adapted for local customs and does not offer clear improvements over familiar, traditional stoves in the metrics important to local cooks, it is unlikely to be adopted and used.

Due to LBNL's background in rigorously testing cookstoves for Darfur, the LBNL stove lab was well-positioned to fill this information gap by providing unbiased evaluations of the performance and usability of various proposed stoves so distributing organizations could make well-informed decisions about which technologies to deploy. The evaluations would characterize the performance of the stoves in terms of efficiency, emissions, and cultural appropriateness. Given the critical situation in Haiti, however, the evaluations had to be completed under the pressure of time, so results could be communicated rapidly to stove distributors and enable them to procure and disseminate the stoves of their choice in a timely manner.

Cookstove evaluation

To meet this timeframe and to provide information that could inform the decisions being made by the NGOs operating in Haiti, compromises had to be made when selecting stoves and choosing metrics to measure and report. Concurrently, new protocols had to be developed to ensure results were applicable to the Haitian stove situation.

Stoves evaluated

NGOs were organizing both short-term relief and long-term rebuilding dissemination efforts. There would be time and opportunity to assess stoves under development for long-term dissemination at a later date, so it was decided to focus on stoves intended for short-term relief efforts, limiting the choice to models that were already available in Port-au-Prince or being considered for relief-operations distribution in Haiti. The final stoves were chosen based on their timely availability and included a traditional Haitian stove for comparison. Images of the traditional Haitian stove and a selection of the improved stoves examined are shown in Fig. 1.

Measurement criteria

Only attributes expected to have the largest impact on cookstove adoption and environmental and economic benefits were chosen for evaluating the stoves. This enabled results to be collected quickly, while still being meaningful. To ensure that the results would accurately portray the stoves' usability and be useful for organizations on the ground in Haiti, the stove team solicited input from Haitian cooks and distributing NGOs on which metrics were most important to them and incorporated those into the testing. The LBNL observation team had learned that the largest concerns for Haitian users were the amount of fuel and time required to complete a cooking task. Distributing NGOs were also interested to know the fuel consumption as well as other indicators of performance such as efficiency and emissions to understand the environmental impacts of the stoves.

Therefore, the metrics chosen for evaluation included the amount of fuel and time required to complete a cooking task, thermal efficiency, and the emission of carbon monoxide (CO). CO is a known major pollutant emitted from charcoal fires; other emissions, such as soot, were not chosen because charcoal fires produce relatively few particles compared to CO emissions and neither the NGOs nor users expressed concern with those pollutants.

Protocol development

A standard test protocol for cookstove comparisons is the Water Boiling Test (WBT), which centers on boiling and simmering water [12,13]. The WBT was used for the first round of stove testing, which compared four improved stoves and the traditional Haitian stove. This round was used primarily to evaluate differences in cooking times and efficiencies. Often a WBT is not representative of local cooking practices, however, so results can be quite different when cooking real food, both in terms of performance and usability. Cooking an actual meal typically requires different cooking styles than those outlined by the WBT, which can lead to errors in the WBT estimates of thermal efficiency; for example, frying food requires much higher temperatures and thermal power than would be estimated by the WBT. In addition, the WBT does not take into consideration if a stove is even capable of cooking the desired meals; for example, if the cultural cooking style requires using large pots, a stove intended for the region should be able to support a large pot and produce enough heat to evenly warm the contents, a characteristic that cannot be captured by boiling water with temperature measured at a single point as is done in the WBT.

Therefore, the development of a second protocol, the Controlled Cooking Test (CCT), was necessary to simulate a more realistic cooking cycle for testing. A CCT mimics the cooking of specific cultural dishes using a scientifically repeatable protocol. No CCT protocol existed for Haitian cooking prior to these trials, so an entirely new CCT had to be developed. From the field visit and detailed discussions with organizations that had worked extensively with the Haitian population, it was apparent that a meal of rice and beans,