An Ethanol-fueled Household Energy Initiative in the Shimelba Refugee Camp, Tigray, Ethiopia: A Joint Study by the UNHCR and the Gaia Association

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Executive Summary

In June 2005, Project Gaia (PG) and UNHCR embarked on a household energy initiative in the Shimelba Camp, Tigray, Ethiopia, to investigate whether the alcohol-fueled CleanCook Stove, powered with ethanol supplied by Finchaa Sugar Company, could provide a solution to the growing concerns over scarce fuelwood resources in the area of the camp, increasing resource conflict between local residents and camp residents, and poor respiratory health among refugees resulting from or aggravated by unhealthful indoor air quality from wood-burning fires.

Initially, 100 ethanol-burning CleanCook (CC) stoves were placed in 100 homes of refugee families who agreed to participate in the three month pilot study. A detailed assessment of stove and fuel use prior to introduction of the CC stove was conducted, followed by weekly and bi-weekly follow-up surveys after the CC stove was introduced. After a visit to the camp in August by the monitoring team, comprised of UNHCR, Refugee Care Netherlands (ZOA) and PG staff, it was determined that the new cooking technology had been readily adopted by the test families and that the stove appeared to be meeting study objectives. Using an interview format, the monitoring team learned that the amount of fuelwood and time spent gathering fuelwood had dramatically decreased. Also, the refugees spoke of having less coughing and eye irritation when using the CC stove, compared to cooking on their traditional three-stone open fire stoves. As a result, PG and UNHCR decided to place an additional 50 stoves in the Shimelba Camp.

A return visit to the camp in December to reassess the decrease in fuelwood collection and use, as a result of the introduction of the CC stove, proved to be supportive of the findings from the August visit. Fifty household energy profiles were created from among the first 100 households, since these households had the most experience with the CC stove. The 50 energy profiles showed a reduction of at least 42% in the amount of fuelwood collected by refugees previous to the introduction of the CC stove. Time savings from less fuelwood collection resulted in women having more time to do other household chores, care for their children, enroll in literacy classes, pursue income-generating activities and other interests that enhance quality of life.

As a result of the positive outcomes of the pilot study, PG (Gaia Association) and UNHCR have embarked on a formal collaboration in 2006 to scale up ethanol stove and fuel use. A scale-up of the project to include additional stoves into another UNHCR camp, the Kebrebeyah Camp, is now underway. When the cost and logistics of ethanol supply are worked out for the Shimelba Camp, more stoves will go to this camp. Given the benefit of fuelwood savings, reduced likelihood of resource conflict, improved indoor air quality in the subject homes, and the positive reciprocal effects on refugee livelihood, the partnership between PG (Gaia Association) and UNHCR is one that should be given greater attention by the donor community, not only for the Shimelba Camp but for other UNHCR installations as well.

Acknowledgements

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Mural of Improved Stoves in Use in Shimelba Camp – The CleanCook and the Improved Injera Stoves Shown on the Wall of the ZOA Resource Center

1. Background

1.1 Location

Shimelba is located in northern Ethiopia, in Tigray Regional State (TRS). The TRS covers some 50,086 m2 across northwestern and northeastern Ethiopia. The region is widely recognized for its diverse settings and agro-ecosystems displaying a wide array of environmental problems and vulnerabilities. These are lands that are fragile and vulnerable to both natural and human generated calamities, ranging from shortage of or erratic rainfall to species and resource base depletion and degradation rendered more acute by the effects of drought.

Shimelba Camp is roughly 35 km from the UNHCR antenna office in Sheraro on the way to Setit Humera, western Tigray. The location of the camp site is isolated. The environmental conditions are difficult. The host population is generally agricultural and light in population density.

The camp is situated at 1,000 m above sea level in a patchwork of cleared land and low density dryland forest. In some directions from camp, refugees can find dead wood for fuel and building materials, usually within 3-5 km of camp, whereas in other directions they encounter depleted woodlands and arid areas, which yield little or no usable material. They must avoid local settlements and their inhabitants in order to avoid bringing trouble to themselves. A ban on the cutting of live wood is enforced by forest guards.

1.2 Demography and Institutional Set up

The Eritrean refugees at Shimelba were relocated from a temporary site at Wa'ala Nhibi in May and June 2004, with the move completed on 12 June 2004. The registered population of Shimelba as of 31 December 2005 was 10,644, comprised mainly of ethnic Kunama (39.5%) and Tigrigna (57.7%), with a small minority of Saho and other groups, as summarized in Table 1. Some 72% of the refugees are male and most new arrivals are also men, meaning that the sex ratio is becoming further skewed and average household size is becoming smaller.

Table 1: Population Data for Shimelba Camp

Ethnic group	Number	%
Kunama	4,206	39.5
Tigrigna	6,144	57.7
Saho	187	1.8
Others	107	1.0
Total:	**10,644**	**100**

The Kunamas are predominantly agro-pastoralists from the lowlands of south-western Eritrea and generally crossed into Ethiopia in family groups in the aftermath of the war between Ethiopia and Eritrea, 1998-2000. The Tigrignas come mainly from Asmara and other urban centers and are typically better educated, more urbanized and accustomed to smaller households, often with some family members absent. The family size in the camp ranges from single person households (over 56%) to those comprising as many as 12 members (0.3%) making an average household size of 1.44.

The camp is receiving new arrivals at the rate of 300 to 400 individuals per month. This is for several reasons, including forced conscription, discrimination and the need or desire to join family members in the camp. Many refugees were in the Eritrean national service and some also have fled in anticipation of being forced to join the national service. Moreover, resettlement activities in Shimelba are known to Eritreans, particularly Tigrignas, who wish to leave the country. This constitutes a major draw for Eritrean Tigrignas to come to Ethiopia. There are also many persons who formally resided in Ethiopia, whether as Ethiopian or as Eritrean citizens, who were deported during the war between the two countries. Subsequent to their deportation, many of these persons returned to Ethiopia as refugees.

The population of Shimelba has now surpassed its designed capacity of 10,000 refugees. UNHCR will open a second camp with the capacity to accommodate an additional 10,000 Eritrean refugees. UNHCR Ethiopia has requested Headquarters for additional funds to develop the new site. To this end, UNHCR HQs recently approved an initial amount of USD $540,774 to implement preparatory construction activities under Phase One of the plan for the establishment of the new camp.

Like most refugee camps in Ethiopia, Shimelba is under the broad control of UNHCR, which takes the responsibility of running the camp through its 'Antenna Office' in Sheraro in partnership with the Administration for Refugee and Returnee Affairs (ARRA), the Ethiopian Government's official refugee agency. Although they function in different roles and capacities, both the UNHCR and ARRA are entrusted to play key roles in sustaining Ethiopia's refugee communities, well beyond day-to-day issues and the provision of basic necessities and the few amenities that can be provided.

It is worth noting that ARRA plays pivotal roles not only as the legal entity representing the government in all issues that relate to the camps but also as an implementing and coordinating agency. Other implementing partners include: The International Rescue Committee (IRC), which operates water and sanitation, education and community services, Refugee Care Netherlands (ZOA), which is responsible for the environment education sector and the Bureau of Agriculture & Natural Resources (BoANR), an Ethiopian government agency that operates environmental management programs in Shimelba with UNHCR funding. Another implementing partner, Gaia Association Ethiopia, is promoting the CleanCook stove and ethanol for cooking.

1.3 Services and Assistance to the Refugees

Food distribution is one of the major components of services. The refugees receive food at regular intervals (once a month) as part of the standard "care and maintenance assistance" package. Medical services, education and potable water are included in the package of basic services provided to the refugee community. Ensuring access to potable water is one of the commitments the UNHCR and its partners have been striving to meet along with basic health services.

1.4 Environmental Interventions

As soon as the camp was established in May 2004, UNHCR began supporting a program of environmental interventions in the camp through the government's Bureau of Agriculture and Natural Resources (BoANR) and Refugee Care Netherlands (ZOA).

BoANR is responsible for the production and dissemination of fuel-efficient traditional fuel (solid biomass) stoves, nursery development and tree planting as well as construction of

terraces and checkdams to contain soil erosion. BoANR is promoting two improved biomass stoves, the stand-alone injera stove and a multi-pot stove that incorporates two large hearths for injera and kita, plus a smaller hearth for sauces and relishes. The stand alone injera stove has been provided by GTZ with funding assistance from the Shell Foundation.

UNHCR is also examining alternative energy options that avoid reliance on solid biomass. The first is liquid ethanol fuel and an accompanying 2-pot "CleanCook" stove, a rugged, durable metal stove, of which 150 units were introduced at Shimelba on pilot basis beginning in June of 2005. The funding for the pilot testing of this stove was provided by a grant from the Shell Foundation. This paper presents the results of that pilot testing.

Another cooking alternative that has been explored was solar energy. Thirty box-type solar cookers have been introduced at Shimelba on a trial basis. The concept of cooking using the power of the sun, which is a free and unlimited energy source, is clearly very appealing. However the study demonstrated that cooker performance has not matched promoters' claims and changes required to traditional cooking practices have been so significant that few refugees have been willing to adopt solar technology, even as a supplementary cooking option. UNHCR concluded that the promotion of solar cookers at Shimelba was unlikely to serve for the purpose intended.

In addition to energy conservation, tree planting and improved stoves and fuel, another environmental intervention has been the promotion of mud blocks for construction as an alternative to wood. Block making is a desirable activity from many perspectives, including environmental protection, income-generation and refugee quality of life.

The final environmental intervention is awareness-raising. Refugee Care Netherlands reached over 7,000 people by the end of 2005 with better awareness of environmental issues and ways to minimize degradation. An Environmental Task Force has been set up comprising UNHCR, government, locals and refugees. Within the camp, environmental training sessions were organized to raise awareness and introduce ideas for rational resource use. A "Roots and Shoots" club has been established to reinforce environmental, community-based awareness raising efforts. A baseline survey of environmental knowledge was carried out with UNESCO-PEER and followed up with the distribution of 2,000 copies of an environmental magazine.

2. Ethanol Pilot Project

2.1 Background

Project Gaia (PG) has been carrying out an 850 ethanol-fueled stove pilot study throughout Ethiopia for over a year and half. PG is a technical working group comprising Dometic AB, the Stokes Group, Makobu Enterprises PLC, the Shell Foundation and others, the purpose of which is to test the feasibility of alcohol fuels for household use in Ethiopia. Thus far, CleanCook (CC) stoves have been placed in homes across all incomes in 10 of 10 sub-cities of Addis Ababa, in UNHCR's Shimelba and Kebrebeyah camps, in the town of Denan in Somali Regional State, and in various institutional settings in Addis Ababa including the Missionaries of Charity Home for Orphan Children with HIV/AIDS. The state-owned FINCHAA Sugar Company has been the sole supplier of ethanol to the project, providing a locally procured, clean and potentially economical household fuel to the stove users.

In June 2005, Project Gaia and UNHCR placed 100 ethanol-fueled CC stoves in the Shimelba camp. The parties desired to ascertain whether this new cooking technology, if made available to the refugees, would positively address the myriad impacts of fuelwood gathering

and use on the lives of the refugees, and also address the environmental impact on the lands and fragile forest ecosystem surrounding the camp. Of particular interest to the Shell Foundation is the health impact of cooking with wood, e.g. poor indoor/outdoor air quality from smoky fires that has been shown by numerous studies to contribute to a variety of health problems, including respiratory disease, asthma and eye infections. Associated with this are the risks of accidental and intentional injury to fuelwood gatherers as a result of the heavy labor of gathering wood and conflict with local residents who seek to prevent or discourage the camp residents from gathering wood. These health risks represent a potential significant hidden cost that camp residents must bear and that also must be borne by the camp managers, who provide health services to the residents. Another hidden cost to the camp managers arises from the exacerbated relations between camp residents and locals created by the conflict over the gathering of wood.

In August 2005, 50 additional stoves were added to the study in Shimelba Camp and 150 stoves were placed in homes in the Kebrebeyah Camp. In October of 2005, Project Gaia Research Studies incorporated as an Ethiopian non-profit organization, the "Gaia Association," in anticipation of bringing additional stoves to the Shimelba and the Kebrebeyah Camps in 2006, as a UNHCR implementing partner.

2.2 The CleanCook Stove and Ethanol Fuel

2.2.1 The Stove

The CleanCook stove, a prototype developed for this study, is adapted from the leading alcohol stove commercially available in Europe, North America and elsewhere. It is durable, constructed of stainless steel. As a result of this study it may undergo further adaptation.

The prototype has two burners, each of which provides 1.5 to 2 kW of heat output, similar to a LP gas burner. The stove has an efficiency rating of 61%. Each burner has its own fuel canister, which holds 1.2 liters of fuel, sufficient for 4 ½ hours of cooking. Thus, 9 hours of cooking is provided with one filling of the stove.

Figure 2: The CleanCook Stove

The stove has been designed for safety and performance. Its fuel canisters are non-pressurized. When ethanol is poured into the canister, it is adsorbed and clings to the surface of a ceramic fiber inside the canister. This unique storage system permits the liquid fuel to be retained in a leak-proof, spill-proof manner. The ethanol moves by capillary action to an opening at the top of the canister and evaporates into a combustion chimney below the burner. When the burner is lit, heating the chimney, the ethanol evaporates steadily, as if under pressure. Although a liquid, the ethanol is actually burning as a gas.

The burner chimney mixes the ethanol with the correct amount of air as it evaporates from the canister, producing a hot, stable flame. The burner flame is adjustable, allowing the user to economize on fuel. The flame regulator is the only moving part on the CleanCook stove and is sturdily built.

2.2.2 The Fuel

Ethanol fuel burns with a smokeless, odorless blue flame. Ethanol has excellent safety properties. These may be evaluated with regard to toxicity, flammability or fire hazard, environmental impacts and cleanliness of combustion. The following information is available from a variety of sources, including the Materials Safety Data Sheet (MSDS) for ethanol, UNDP World Energy Assessment, USEPA publications and Perry's Handbook of Chemistry.

Toxicity: Ethanol can be effectively denatured with a colorant and a bittering (tasting) agent to render it unpalatable for ingestion. The ethanol was not denatured for the pilot study; however, it is recommended that it be denatured once scale-up of the stove program begins. Ethanol is generally not considered toxic except at higher doses. The threshold limit value (TLV) for prolonged exposure to ethanol vapors has been set at 1000 ppm by U.S. and European regulatory agencies, while the corresponding TLVs for gasoline and kerosene are 300 and about 20 ppm respectively. Contact with the skin is not considered a risk.

Flammability and Fire Hazard: Accidental fires may occur when flammable vapor increases to concentration (Lower Flammability Limit or LFL) at which ignition will occur. A higher value for LFL is considered safer. Ethanol has an LFL value of 3.3% in air at room temperature while kerosene has an LFL of 1.7% and gasoline of 1.4%. Auto ignition temperature for ethanol is much higher than for kerosene and gasoline. Ethanol vapors are light and disperse quickly. These factors make the explosion hazard for ethanol much less than for gasoline and kerosene.

The severity of a kerosene fire is much greater than an ethanol fire. The kerosene fire radiates intense heat, while an alcohol fire burning in an open environment takes on excess air and burns "lazily" with diminished heat. Alcohol fires are extinguished with water while kerosene fires are spread with water.

Environmental Hazards: Ethanol mixes readily with water and quickly degrades in the environment. Hydrocarbon fuels do not mix with water and do not degrade rapidly. Studies indicate that ethanol is non-toxic to a variety of aquatic plants and animals tested, while gasoline and kerosene are very toxic (USEPA).

Products of Combustion/Air Quality: The long list of products of combustion of wood and kerosene include smoke and soot (particulate matter), benzene, butadiene, formaldehyde, carbon monoxide, polycyclic aromatic hydrocarbons, dioxins, furans, etc (Kirk Smith, UNDP World Energy Assessment). The primary products of combustion of ethanol are carbon dioxide and water vapor.

2.3 Project Objectives

Firewood is the most familiar fuel to refugees in Ethiopia. They have well-adapted cooking systems based upon firewood and their pots, stoves and food preparation techniques are designed around this fuel. However, most of the refugees still use the traditional 3-stone fire with thermal efficiencies of below 10%, which requires a large quantity of firewood.

Meeting energy requirements for cooking is an important part of every refugee family's daily burden and lack of firewood is causing serious problems in most of the refugee camps in Ethiopia. Refugees either have to sell part of their ration to meet their firewood/charcoal needs or they must place themselves at personal risk in trying to gather the firewood, since fuel harvesting has become a source of conflict with local people.

Women and children are the first victims because they do most of the firewood collection. Often they have to walk 5-10 km or more in the hot sun to gather enough wood. This is challenging, laborious and dangerous work. It is commonplace to fall under a heavy burden carried over a rough terrain. Thus accidental injury is commonplace. But often the injuries are purposeful. Women and children are frequently harmed by local people or by policing authorities while out gathering wood.

Not to be overlooked is the health damage caused particularly to women and children by the smoke from cooking fires, which contains not only very fine soot particles but also toxic chemicals. As women and girls do most of the cooking and as young children are usually with their mothers during this task, it is the women and children who receive the greatest exposure to the harmful soot and gases produced by cooking fires.

UNHCR seeks to introduce new technologies that reduce current demand for firewood through improved end-use efficiency. The key strategy has been to expand the dissemination of more fuel-efficient stoves to refugee families. These end-use interventions have been supplemented by planting fast growing trees, some of which produce firewood after 3 to 5 years. Along with improved stoves, in recent years UNHCR and its partners have been promoting a range of simple energy conservation practices and alternative energy sources for cooking.

Towards alternative energy, in 2005, UNHCR established a partnership with Project Gaia to pilot test the ethanol-powered Clean Cook stove in refugee settings. To this end, some 300 stoves were placed in Kebrebeyah and Shimelba refugee camps.

The main objective was to test whether these stoves could be a viable cooking options in refugee situations and, if so, how best to adopt them to provide the maximum amount of benefits to the users. The specific objectives of the project as set out by Project Gaia and UNHCR include:

- Reducing firewood consumption and the associated labor for individual families;
- Reducing firewood-collection-related exposure to rape and other gender based violence that especially affects women and children;
- Reducing health hazards arising from poor quality fuels;
- Helping to encourage production of CleanCook stoves in Ethiopia in collaboration with a local manufacturer or to take other steps to assure access to an appropriate stove.

2.4 Project Evaluation

As with any new idea that moves to the application stage, it is necessary to assess its failures and successes over time to determine its plausibility beyond being that of a concept. Project Gaia with UNHCR has carefully crafted an evaluative process that measures such things as fuels usage before and during CC stove use, family size, user satisfaction, willingness to pay per liter of ethanol, cooking habits and times and user safety, among numerous other criteria.

2.4.1 Evaluations, Objectives and Criteria

A Baseline Survey is conducted in the selected study households prior to the introduction of the CC stove, the purpose of which is to assess current cooking practices, equipment and costs. After the stove is placed in the home, PG surveyors go into the home at least once a week to record cooking habits, experience with stove and fuel and the amount of ethanol fuel used in the week. Additionally, a more involved survey is carried out every two weeks. The

purpose of the Bi-weekly Survey is to investigate the comparative practices of cooking with ethanol and with other fuels while the CC stove is in the home, and the extent of the reliance on the CC stove.

2.4.2 Evaluation Methodology and Process

2.4.2.1 Sample size

Ninety-nine of 150 households were selected to participate in the complete study. The ethnic composition of the households is: 58 Tigrigna, 38 Kunama, and 3 Saho. The selection of the households was based on the following criteria: mud block houses, households' participation in the seed planting activities, and ethnic composition of the camp.

2.4.2.2 Data Collection

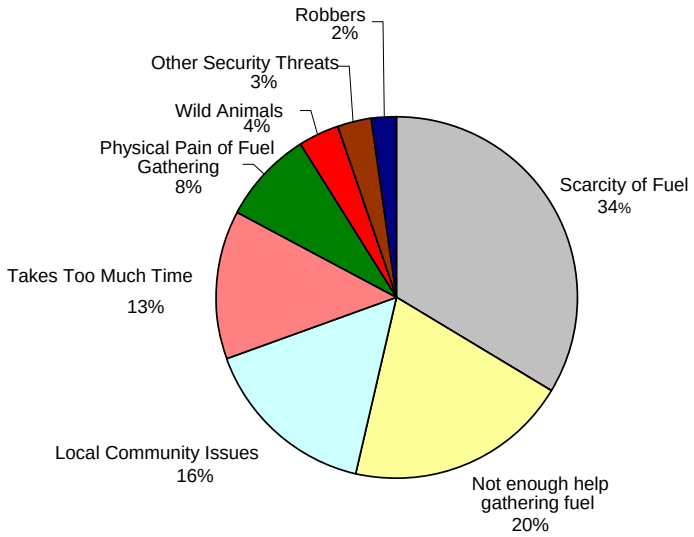
To assess CC stove use and its effect on the lives of the refugees, Project Gaia and UNHCR used a qualitative and quantitative approach for the study. In addition to the Baseline Survey, Weekly and Bi-weekly surveys were carried out in accordance with study guidelines. Narratives were collected from 16 households in August 2005 and a specific Household Energy Survey was conducted in December 2005. Also, 50 Household Energy Profiles were compiled in December 2005. A group discussion with study households was facilitated by UNHCR during the December 2005 visit.

3. Findings

3.1 The Baseline Survey—Problems Faced by Fuel Gatherers

According to the baseline survey, 52% of the study households primarily rely on gathered fuelwood for cooking. Other fuels gathered by households are: charcoal, sawdust, roots, eucalyptus leaves, and agri-residue. When asked about the problems they face when gathering fuel, these fuel gathering households gave the following responses:

Table 2: Problems Faced by Fuel Gatherers in the UNHCR Shimelba Camp



Scarcity of Fuel: The main concern of fuel gathering households is scarcity of fuel, which requires families to walk farther and farther for wood and other biomass fuels, thus increasing tensions with the local community, increasing safety risks, and creating larger time

constraints for the families themselves. The CC stove reduces the need for refugees to gather fuel from the local community and reduces demand on the scarce resource.

Not Having Enough Help: The problem of not having enough help raises concerns that children will become more necessary to help gather fuel, thereby taking them away from educational or social development activities, as well as placing them at risk of physical injury due to carrying heavy bundles and walking long distances, or of assault, particularly if it is an unaccompanied girl who goes out to gather wood.

Local Community Issues: Reports of conflict with the local community over access to wood, whether induced by resource scarcity or ethnic relations, have been widely reported at Shimelba and this concern seems to be the source of the most anxiety and fear in the daily lives of those interviewed, as was evident in their emotions when talking about it, especially for the Kunama women fuel gatherers. While the CC stove does not eliminate all fuelwood gathering, as a wood-fired stove is preferred for baking injera, the CC stove does alleviate some of the fear and anxiety felt by the refugees because they are not collecting wood as often during the week. Consequently, the use of the CC stove is assisting in reducing the incidents of conflict between the local community and the refugees.

Takes Too Much Time: Fuel gathering takes a great deal of time. As fuelwood and brushy biomass become scarcer, households have to travel farther and take more time to gather fuel. This time could be better spent on income-generating activities, education and child care.

3.1.1 In Focus: Gender-Based Violence

> *"While refugee situations present problems of safety to all refugees, women and their dependents are particularly vulnerable. Their physical security is at risk both during flight and after they have found refuge . . . During flight, refugee women and girls have been victimized by pirates, border guards, army and resistance units, male refugees, and others with whom they come in contact . . . Violence against women and girls does not necessarily abate when refugee women reach an asylum country . . . Unaccompanied women and adolescent girls are particularly at risk of such sexual and physical abuse" (UNHCR, Section III, points 30, 31, 33).*

In December 2005, staff conducted a follow-up survey with 50 of the initial 99 study households and the following threats were cited as problems when gathering wood: 14 cited robbers, 4 cited forced payments, 1 cited forced sexual favors, and 6 cited sexual assault. Security threats cited as 'Other' in the initial survey may, therefore, include the threat of rape, which has been a recognized problem in some refugee camps in the world and is underreported in every society. The threat of such violence to refugee women, who hold the primary responsibility of fuel gathering, is well-documented. "Refugee situations are beset by gender-based violence…" (USAID 22).

In comparison with the obvious problem of fuel scarcity, the psychological fear of security threats and bodily harm may be significantly underreported even though the fuel gatherers questioned may have been harassed or sexually assaulted. A woman who has been raped/harassed at any point during flight or during her stay in a camp may suffer from Post Traumatic Stress Disorder (PTSD). Because she would feel vulnerable when gathering fuel, and this could trigger PTSD episodes. Acute fears endured on a daily basis can cause psychosomatic symptoms, such as pelvic pain, headaches, and chest pain.

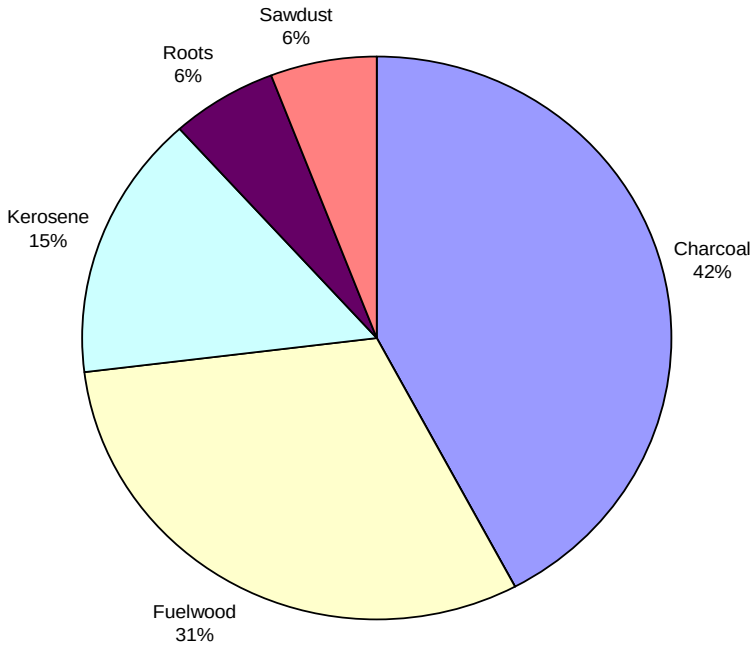
Physical Pain: Physical pain of fuel gathering includes neck, back, leg, knee, and foot pain. This pain can have serious long-term health effects, particularly when men, women, or children are walking long distances and carrying the fuel by foot. Most fuel gatherers do not have access to a mule/donkey/camel, so the load is often carried by a person. On a daily basis, this can cause severe strain on the human body.

Other Problems Cited by Fuel Gatherers: Wild animals (like snakes), 'other' security threats, and robbers were cited as problems by fuel gatherers, and a source of short- and long-term health effects, whether physical and/or psychological. Fuel gatherers are occasionally physically harmed by a wild animal.

3.2 The Baseline Survey—Fuels Purchased by Study Households

Sixty-nine of the 99 study households reported purchasing some amount of fuel, and many households purchase more than one fuel to meet their cooking needs.

Table 3: Fuel Purchased by UNHCR Shimelba Camp Study Households (30 households did not report purchasing any fuel)



The purchased fuels by the study households are noted as follows:

- 58 households purchase charcoal, representing 42% of the purchased fuels;
- 42 households purchase fuelwood, representing 31% of purchased fuels;
- 21 households purchase kerosene, representing 15% of purchased fuels;
- 8 households purchase roots, representing 6% of purchased fuels;
- 8 households purchase sawdust, also representing 6% of the purchased fuels.

Since 70% of the households in the UNHCR Shimelba Camp Study purchase some cooking fuel, this shows a significant demand and willingness to purchase fuel for stoves.

3.3 Relevance/Appropriateness of the Project

A visit to Shimelba on 24 August 2005 by Project Gaia's O'Brien and Murren with UNHCR and ZOA staff for the purpose of interviewing CC stove users to assess the progress of the study proved quite positive. After two months of using the stoves, the sixteen households interviewed in depth indicated in their responses the promise for the ethanol stove to address key issues facing the refugees on a daily basis. All households showed a decrease in the amount of time spent collecting wood for cooking and a decrease in the amount of wood collected. The people interviewed uniformly stated that because of the new stove they did not have to go out and gather fuel as often, which, they explained, caused them to worry less and in fact reduced incidents of conflict with militias from the local village.

"The CC Stove is more efficient than the other stoves. Before the CC Stove, I spent all day cooking, and now I cook about two hours a day. With my free time from cooking, I weave mats to sell and I go to the literacy program offered by the IRC [International Rescue Committee]. Also, I care for my three children with my free time". --Margareta

Figure 3: ***Project Gaia Surveyors with Margareta holding income-generating handicraft and her child.***

It was evident that a stove *not* fueled by wood, an improved fuel stove, could indeed alleviate two major challenges facing the people of Shimelba Camp and also the administrators and managers of the camp: scarcity of fuelwood in the camp's environs and environmental conflict with the host community. By reducing the heavy demand for fuelwood to meet daily cooking needs, the CC stove can help to solve the serious dilemma of how to assure that the refugees are provided for while also giving consideration to the host community and to the protection of natural resources that the host community feels belong to them.

3.4 Fuelwood Savings, Time-bound Changes and Other Impacts

The use of the ethanol-fueled CleanCook stove has led to significant fuelwood use savings, which has led to a decrease in the amount of time spent collecting fuelwood. This new-found time has created opportunities for camp residents.

3.4.1 Fuelwood Savings

The 6-7 December 2005 visit to the camp by Project Gaia and UNHCR monitors confirmed the amount of fuelwood being saved with the CC stove. Interview surveys were conducted in 50 of the 99 households. Data was compiled and analyzed. Interview questions ranged from the principal inquiry of how much fuelwood was being collected and used to user satisfaction with the CC stove and CC stove safety compared with other stoves in use in the camp.

A more systematic survey was carried out over a two week time period during which each of the 50 households was monitored on a daily basis. Fuelwood use was measured daily during

one week when no ethanol was available and during the next week when ethanol was available for cooking.

Fuelwood Collection: The data gathered from the fifty households showed that, prior to the introduction of the CC stove, 40 of the homes with a combined total of 82 fuelwood gatherers collected an average of 16,090 kg/month. A total of 196 people live in these 40 households; therefore, the amount of wood consumed as an average over the served population was 82 kg/month or 2.7 kg per person per day. Prior household energy surveys conducted by the UNHCR have shown a daily average of about 2.1 kg per person, or a monthly average of about 63 kg/person.

Of the 50 households, 10 reported that they are fuelwood purchasers. Fuelwood purchasers in the camp buy wood from the camp gatherers and from sellers who come into the camp from surrounding communities. A possible explanation for the higher wood gathering figure above, of 2.7 kg per person, is that some of the wood being gathered by the 40 homes is for sale to others in the camp. Within the 10 purchasing households, the purchased wood was used to cook for 56 people. If we make the assumption that 4 of 5 homes gather and one in 5 homes purchases, and that the amount of fuelwood gathered is consumed by all 50 homes, then the daily consumption figure per person drops to 2.13 kg (63.85 kg/person/month). This figure is equal to UNHCR's 2.1 kg/day average.

Fourteen of the 50 households reported that a combined total of 46 neighbors used the CC stove from time to time for cooking needs. The total number of people reached in the study is therefore increased from 252 to 298 camp residents. Given that the total number of people reached by the CC stove may in fact include fuelwood gatherers, fuelwood purchasers *and* neighbors (meaning that more fuelwood use may have been offset than we can calculate here), the 16,090 kg/month figure cited above can be considered conservative.

Additional data on fuelwood gathering and use patterns are being obtained. For this study, we have assumed the figure of 16,090 kg of fuelwood gathered monthly to meet the demand expressed by 50 households. How much wood is being gathered to meet the cooking needs of the entire camp? How will the use of the CC stove affect this fuelwood gathering and how will it influence fuelwood use patterns within the camp?

Table 4: Fuelwood Use (from Household Interviews Conducted Dec 05)

	Before CC Stove	**During CC Stove**	**% Reduction**
Total # of Fuelwood Gathering Households (out of 50)	40	33	17.5%
Total # of Fuelwood Gatherers	82	68	17%
Total Amount of Wood Collected in One Month	16,090 kg	5,821 kg	64%
Total Distance Traveled in One Month	4,996 km	1,968 km	61%
Total Time Spent Collecting Wood	1,659 hours	732 hours	56%

After introduction of the CC stove, 33 households with a combined total of 68 gatherers reported that they still collected fuelwood, primarily for injera cooking. This is a reduction of 7 households and 14 gatherers. The total amount of collected wood dropped from the before CC stove total of 16,090 kg/month to 5,821 kg/month collected while CC stoves were in operation in the homes. This is a 64% reduction in the amount of fuelwood collected in one month by 50 homes.

In addition to the interviews, the same 50 households participated in a two-week survey where fuelwood, charcoal and ethanol quantities were measured daily. During the first week, households used their traditional stoves only, as no ethanol was available for use. During the second week when ethanol was available, the households were asked to cook as they had been cooking with the CleanCook stove, in other words, they were to use the CC in the way that it naturally fit into their household cooking pattern (as established by practice), using whatever stove and fuel fit the task at hand.

Table 5: Total Weekly Fuelwood Use from Daily Measurements across 50 Households

Total fuelwood consumed before CC stove introduction	Total fuelwood consumed after CC stove introduction	Total ethanol consumed in addition to fuelwood during second week
2878.05 kg	1666.4 kg	267 liters

At the end of the two week survey, it was determined that the amount of fuelwood used for cooking was reduced by 42%. Fifty households representing 227 people showed an average amount of fuelwood used per person per day decline from 1.81 kg to 1.05 kg as a result of using the ethanol stove.

The amount of ethanol consumed during the second week was 267 liters or 5.34 liters per family. This is 1 to 1.66 liters below what might be expected (based on stove trials in homes in Addis Ababa) but represents a reasonable figure resulting from careful use. This ethanol use across the 50 families apparently displaced 1212 kg of fuelwood use, which represents 4.5 kg of wood displaced by each liter of ethanol.

The use of the CC stove in the Shimelba Camp thus is shown to lead to a reduction in the amount of fuelwood collected and used for cooking. It is hoped that this reduction will yield not only positive environmental impacts, but also benefits with regard to daily burden of labor, daily commitment of time, reduction in exposure to harmful smoke and gases and reduction of risk involved in the gathering of fuelwood. It is also hoped that this will reduce burdens associated with camp management, including costs of health and crisis care.

3.4.2 Labor saved

The reported distance and amount of time traveled while collecting fuelwood before the introduction of the CC stove equaled 4,966 km/month and 1,659 hours per month. During CC stove use, the distance and amount of time traveled in one month were reduced to 1,968 km and 732 hours. These represent dramatic savings. There may be a compounding effect in that smaller quantities of firewood would be more easily gathered closer to camp, while larger amounts of firewood would require gathering further away from camp.

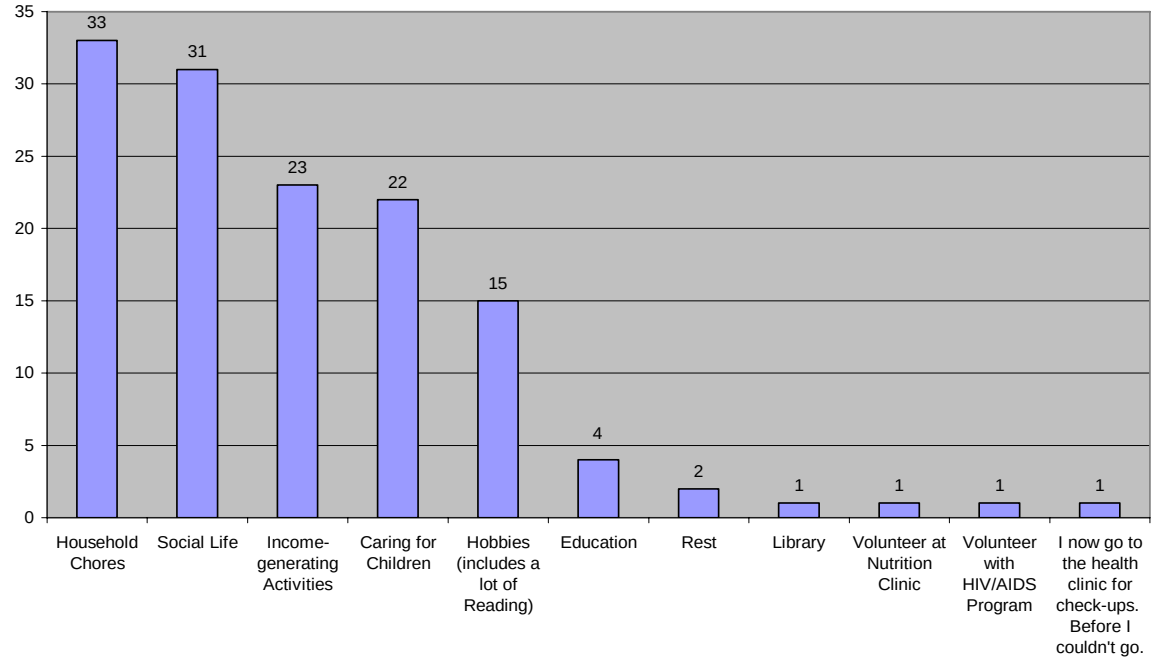
The interviews showed that trips per month decreased in all surveyed households. This new found free time for the fuelwood gatherers resulted in their having more free time to give to their children, take on income-generating activities and pursue personal interests. According to the interviews, refugee personal well-being benefited as a result of the use of the CC stove in the homes (see **Table 6**, following page).

3.4.3 Health and Social Impacts

The majority (69%) of all cooking occurs inside the typical Shimelba Camp home, thereby raising concerns over Indoor Air Pollution (IAP) from cooking, particularly since the average home is 3m x 4m to 4m x 4m with few or no windows. An additional 3% of cooking occurs in an open air room attached to the house, with the result that cooking pollutants easily enter

the house. While 28% of cooking occurs outdoors, the cooking pollutants from these fires still affect the health of the primary cook as well as anyone in and around the smoke, most often the children. Since there is not much space between homes and there are no trees or other barriers, whether natural or manmade, to block the pollutants, this 'courtyard' smoke travels to neighbors and into homes.

Table 6: Activities Resulting from Time Saved with the CC Stove and/or Time Saved with Decreased Fuelwood Gathering - 50 HHs



The exposure to a high concentration of smoke inside the home is greatly reduced by the CC stove, as the primary products of combustion of ethanol are water vapor and carbon dioxide. It is significant that 94% of the fuel gathering cooks perceive the gathered fuel to have a high or very high negative impact on their health. Also, 79% of all fuel purchasing cooks believe that the purchased fuel has a high or very high negative impact on their health.

Eighty-six out of 99 primary cooks reported one or more health problems, and 74 of these 86 cooks believe that smoke from their stove is a cause of their health problem(s). Out of these 86 cooks, 74% report a cough, which is symptomatic of respiratory problems caused by IAP. Sixty-four percent of these 86 primary cooks suffer from headaches, which can result from a lack of oxygen; 50% of them experience eye irritation, which can be linked to their time spent cooking and raises concern of potential cataract problems; 31% of them suffer from shortness of breath, which can be symptomatic of respiratory and cardiovascular problems; 21% have constant phlegm (which can reduce airflow); 12% suffer from backaches (possibly from fuelwood gathering); and 1% of the cooks suffered a heart attack. In addition, mothers often carry young children on their back while cooking, so infants and children may spend several hours breathing cooking smoke on a daily basis (Bruce 13).

Figure 4: Kunama Woman with Baby

The implications of IAP, including its effects on others in the household, are evident, and cause considerable demand for the health care system in the refugee camp. Only 13 of the 99 primary cooks either reported no health problems or did not reply to the question. The high number of primary cooks reporting health problems highlights the medical costs (short-and long-term) associated with IAP from cooking in the Shimelba Camp. Many, if not all, of the reported health problems may be preventable or ameliorated if refugees have access to a clean fuel like ethanol.

Addressing refugee access to health care, the UNHCR states:

> "There are also logistical problems that impede access to health care for refugee women. Inconvenient clinic hours may prevent women from coming for health services or bringing their children. Other time-consuming responsibilities limit women's flexibility [to access health care]" (UNHCR, Section IV, Point 101).

The time spent gathering fuel for daily cooking limits the access or primary fuel gatherers to medical treatment. Indeed, one Shimelba woman in a December 2005 stated: "With the saved time from the CC stove, I now go to the health clinic for check-ups. Before, I couldn't go." Thus, the use of the CC stove should both decrease health problems and allow better access to medical treatment.

Air Quality tests conducted by Project Gaia in Shimelba Camp, Bonga Camp and in Addis Ababa homes have measured high levels of soot and carbon monoxide (with associated gases) produced by wood, charcoal and kerosene stoves. No post-intervention measurements have as yet been taken in refugee camp homes but a number of such measurements have been completed in Addis homes in low and medium income sectors. These measurements show very substantial air quality improvement with the CC stove. These results are available in the Addis Ababa pilot study reports.

3.5 Stove and Fuel Safety

Across approximately 22,500 stove test days, there were no accidents or injuries reported with the stove, and no accidental fires or mishandling of the liquid fuel. While there were several stove malfunctions, these were minor and did not give rise to dangerous situations. The users uniformly rate the stove as "Safe" or "Very Safe."

4. CleanCook Stove User Satisfaction

4.1 How Users Rated the Stove

The 50 households surveyed in December were asked a series of questions regarding CC stove efficiency, safety and performance compared to other stoves used in the camp. Regarding CC stove 'Heat Output' and 'Speed of Cooking,' the respondents were given four possible answers: Very Satisfied, Satisfied, Unsatisfied, Very Unsatisfied. For Heat Output, 47 households responded with "Very Satisfied" and 3 offered a "Satisfied" rating. Speed of Cooking scored similarly well with 41 households saying they were "Very Satisfied" and 9 households giving a "Satisfied" response.

Compared to wood-burning and charcoal stoves used in the camp, all households scored the CC stove as "More Efficient" in Speed of Cooking, with 80% of these giving the stove a "Much More Efficient" rating. Not one household stated that the CC stove was "Equally Efficient" or "Less Efficient" than their wood-burning and/or charcoal stoves.

CC stove users judged their new ethanol-fueled stove to be safer than their other stoves. Each of the 50 households recorded that the CC stove was either "Much Safer" or "Safer" than the wood-burning and charcoal stoves. Citing less anxiety about burns to themselves and their children, possible house fires from wood and charcoal fires, ease of CC stove use, and the innovative safety features of the CC stove canister, many expressed an improved sense of well-being and safety when cooking.

4.2 Factors Influencing Usage

While 26 of the 50 surveyed households stated that they use the stove because it is freely available and 32 to the 50 said the same for ethanol, 43 of the 50 households said they would continue to use it because it "Cooks Faster" and 41 of 50 households cited "Saves Time" as a reason why they would continue to use the CC stove. Thirty eight of 50 households said the CC is "Healthier" than other stoves and 34 of 50 said the CC stove is "Safer" than other stoves. All users said they would continue to rely on the stove if it were to remain available to them.

Table 7: Satisfaction matrix for CC stoves

User Evaluation 50 Homes	Heat Output	Speed of Cooking	More Efficient	Safer	Healthier
Very Unsatisfied					
Unsatisfied					
Satisfied	**3**	**9**	**10**	**16**	**12**
Very Satisfied	**47**	**41**	**40**	**34**	**38**

	Heat Output	Speed of Cooking	Saves Time	More Efficient	Safer	Healthier	Free Stove/ Fuel	Would Continue to Use
Factors Influencing Usage		**43 of 50**	**41 of 50**		**34 of 50**	**38 of 50**	**26 of 50** **32 of 50**	**50 of 50**

"Speed of Cooking/Saves Time" seemed to score well among the women surveyed. Likewise "Safer/Healthier" also scored well. This is an indication that these issues are important to the cooks and gathers.

4.3 Beneficiaries' Perspective—What Should Be Changed About the Stove?

Flame Not Spreading at Low Settings: The principal request for change relates to the flame regulating mechanism. This regulator is a flat plate with a concentric ridge and bevel that slides over the evaporative surface of the fuel canister. It is under spring tension created by its tempered steel arm that is riveted to the stove structure so that it covers the fuel canister firmly when closed. The tempered steel arm rotates on the rivet to move the regulator to an open or to a closed position or to settings in between. As the evaporative surface of the fuel canister is covered more and more, it reduces the amount of ethanol evaporating into the combustion chimney and thus reduces the flame.

Complaints were received by users that at the low setting (regulator almost closed) the ethanol flame would not spread well but would provide heat at only one side of the burner. They asked if there was a way for the flame to be spread or distributed more uniformly at low settings (as at high settings).

Low settings provide optimum fuel conservation. Some users may not be turning the stove burner down to a suitably low setting for their cooking or simmering task because they are concerned about the heat not being adequately spread. If this is the case, this may inhibit fuel conservation and may prompt the cook to use too hot a burner.

This problem may be aggravated by dirty canisters. Some of the alcohol received from Finchaa Sugar has been contaminated with fusil oil (an ester present in technical alcohol if not expressly removed). This fusil oil does not combust completely and carbonizes the evaporative surface of the canister. This carbon creates a cake or crust that impedes the evaporation of the alcohol. This seems to aggravate the problem of the flame not spreading properly. It was noted that new canisters and clean canisters do spread the flame reasonably well even at low settings.

Users have asked whether the regulator can move from both sides and close in the middle (a scissors action), wondering if this would spread the flame more effectively.

Burners Farther Apart: Some users have requested a stove body with the burners placed farther apart so that large pots can be placed on both burners.

Turning Stove Upside Down to Place Fuel Canisters: Many users have asked for an easier way to remove the canisters, refill them and replace them in the stove. Users have complained about sharp edges at the bottom of the stove and the fact that there are no handles to facilitate picking up the stove and turning it over. When the stove body is hot, this makes it difficult to grasp the stove and turn it over.

Turning the stove over to extract and refill the fuel canister is a safety measure as well as an economical design element. When the stove is turned over it requires turning the fuel canister over to place it in the stove. If the cook has overfilled the canister, the excess ethanol will spill out and quickly evaporate. Also, by having to turn the stove over, the cook is forced to turn off the stove. The stove should be off when any refilling takes place.

Request for One-Burner Stove: Many users requested a one-burner stove.

Request for Stove to Cook Injera: Many users would like to cook injera on the ethanol stove. The traditional injera for the Shimelba Camp requires a full-sized mirte, while the traditional mirte for Somali people, used in the Kebrebeyah Camp, is smaller. This smaller mirte works well with the CC stove. The larger mirte does not work well because it does not spread the heat adequately but has a hotspot above the CC burner. Thus residents of Kebrebeyah Camp have been using the ethanol stove for injera cooking while the residents of Shimelba Camp have not. It is hoped that a mirte or grill could be designed for the CC stove that would cook the full-sized injera.

Figure 5: Woman Cooking Injera

Injera cooking in the Shimelba Camp (and generally throughout much of Ethiopia) is responsible for at least 50% of the fuelwood demand and possibly somewhat more. An improved injera cooker has been brought to the camp, but this of course still creates a substantial demand for fuelwood. An ethanol injera cooker would offset this sizeable fuelwood demand as it appears to have done in the Kebrebeyah Camp.

4.4 Problems Noted with Prototype Stove

Ethanol is Dirty: The Ethanol received at the Shimelba Camp was Technical Grade ethanol which is 95% ethanol, 4.5% water and about 0.5% or less other constituents, such as higher alcohols and trace amounts of organic compounds. Normally Technical Grade ethanol is adequately clean for use in the stove. The water in the ethanol does not cause a problem.

This ethanol, however, contains a type of oil or ester, called fusil oil, which is a natural product of the distillation process and which is normally removed from the alcohol at the distillery. However, this shipment of ethanol did not have the fusil oil removed.

The result has been to dirty the fuel canister over time with unburned carbon and with the fusil oil inhibiting the capillary action of the ethanol within the fuel canister. The fuel canisters have become caked with an oily carbon at the top of the canister. This is reducing the function of the canister and thus the quality of the burner flame. This result has begun to show itself after about 6 months of use.

The dirty ethanol with fusil oil content will produce higher levels of CO in the combustion gases. This has been picked up by our air quality monitoring equipment. The fusil oil will also cause the ethanol to burn with a yellow flame rather than a blue with yellow tips.

The solution is as follows. Henceforth more fully refined ethanol, the "Power Alcohol," which is 99% ethanol and 1% water with effectively no higher alcohols or other constituents, should be used. This cleaner ethanol should be specified for all subsequent deliveries.

Use of the 99% ethanol will clean the unburned carbon and fusil oil out of the dirtied canisters. Another alcohol, methanol, may also be used to clean the canisters. After several cleanings they should return to full function. The pure alcohol will act as a solvent and will dissolve and remove the fusil oil.

The remaining Technical Grade ethanol at the camp should be filtered through cotton cloth to remove as much of the fusil oil as possible. This appears to be quite effective. Once filtered, this ethanol can be used.

When we move to scale up, all deliveries of ethanol from Finchaa Sugar should be accompanied with a lab report certifying the cleanliness of the ethanol. Only the fusil oil is a problem. All ethanol received should be free of this oil. To avoid any problem, Power Grade ethanol should be specified.

Regulator Malfunctions: Occasionally a stove regulator malfunctions, with the result that the regulator will not extinguish the burner flame. This happens most often when the stove is used for long periods and the stove body becomes heated from the reflected heat of the pots. Sometime, when the regulator is closed but has failed to extinguish the flame at the canister, the flame will travel sideways and may ignite the other canister.

Users have learned to deal with this safely. They turn the stove over and remove the canisters and blow them out or cover them with a plate to extinguish them. The situation is not intrinsically dangerous, as the alcohol flame will not flare up and the alcohol in the canisters will not leak out. However, it is annoying, may disrupt the cooking routine and wastes ethanol.

The solution is as follows: The user should be taught to manipulate the regulator rapidly, thereby encouraging it to seat properly over the fuel canister and extinguish the flame. The

regulator and burner chimney should be kept clean. If the edge of the regulator is clean and free of carbon, it will slide more easily and seat properly in most instances.

The factory should review this problem, test the stove under very hot conditions (when the stove body becomes heated) and should explore ways to redesign the regulator so the chance of malfunction is decreased (possibly the regulator should be increased in diameter).

When the stoves are disseminated, proper training should be given to teach stove users how to extinguish the burner flame in the event that the regulator fails to close properly.

Fortunately no accidents or injuries have occurred as a result of this regulator malfunction. This is an indication of the safety of the stove and of the fuel. Nevertheless, this malfunction should be addressed.

On very rare occasions a regulator has been found to be loose or in some manner physically damaged after wear and tear on the stove. The user should be instructed to turn this stove in for repair, in exchange for a stove with the regulator in good working order.

A one burner stove will eliminate the migration of flame from one canister to the next in the event that there is a regulator malfunction.

Handles should be placed on the stove body to promote ease of picking up and turning over.

5. Conclusions

The proven success of the CleanCook stove in the UNHCR Shimelba Camp is promising and provides a foundation on which to build. Fuelwood collection and consumption have been substantially reduced in those homes that are using the CC stove. The interest of neighboring families, and indeed the entire camp, is high. From the results of our sample and from the general response in the camp, there is every indication to believe that the favorable results produced by the stove would hold true for all homes into which the CC stove were to be introduced.

A reduction in the fuelwood needed for cooking means that camp residents are making fewer trips outside of the camp to gather wood. This in turn should lead to a reduction in the number of instances of tension and conflict between the residents and members of the local community, who have become competitors for the fragile biomass resource of the area. Because most of the gatherers are women and children, the incidences of gender-based violence, assaults and rape (and the fear of falling prey to these events) should also be reduced. Fewer trips to gather wood also means that less wood is being cut, which will alleviate demand on the biomass resource. Additionally, time freed from fuelwood gathering and reduced cooking times has resulted in women cooks and gatherers having more time for education, social life, childcare, and income-generation. Use of the ethanol-powered CC stove in the Shimelba Camp directly improves the welfare and livelihood of the people living in the camp. The improvement is immediate with the introduction of the stove.

The stove appears to have been well proven by the pilot study. While suggestions have arisen for the improvement and further adaptation of the stove, it has been shown to be safe, efficient, considered desirable by the camp residents, Kunama, Tigrigna and Saho alike, and able to serve all of the cooking needs of the camp residents with the exception of injera cooking. Since injera cooking requires about 50% of the energy demand for cooking in the typical Ethiopian family, it is expected that the CleanCook stove will reduce biomass

consumption about 45% to 50%, but that until such time as injera can be cooked on the ethanol stove, the amount of fuelwood displacement will probably not rise above this amount.

However, a reduction in biomass gathering and use by about 50%, as has been pointed out, brings with it a number of other gains, including reduced resource conflict, reduced harm and injury to fuel gathers, increased discretionary time for women and girls and a host of other benefits. Not the least of these is reduced exposure by women and children to smoky fires and indoor air pollution, which has been shown in numerous studies to contribute to respiratory infections and diseases, asthma, eye, nose and throat irritation and other health problems. Interviews with stove users yielded frequent comments about reduced symptoms such as coughing, breathing problems and eye irritation. "Healthier" scored high on the satisfaction matrix compiled across the 50 families.

6. Recommendations for Further Study

UNHCR considered the feasibility of implementing a cost-sharing mechanism to offset the costs of ethanol to the camp residents. Indeed, ethanol cost, not stove cost, is the largest cost of this program, representing 60+% of the first year cost, and 100% thereafter for the life of the stove (expected to be 5+ years). A question asked during the 50-household assessment conducted in December 2005 was 'What can you contribute per liter of ethanol fuel?" A slight majority of households, 28 of 50, stated that they could contribute something, the average of which over the total 50 households amounted to only 0.35 ETB. Given this small amount, it is uncertain whether households really have the ability to cost-share the ethanol at this time. (If ethanol were sold, would some households gather and sell wood to purchase ethanol?) A more thorough investigation into a cost-sharing mechanism in the camp should be completed. Determining the amount of money spent and made on fuelwood purchases and sales would contribute to understanding purchasing power in the camp.

If the pilot study stoves are withdrawn from the Shimelba Camp without an ethanol stove program following immediately, which may be necessary because of lack of resources, interviews and dialogue should be conducted with the pilot study families and the camp's refugee governance committee. How families who have come to rely on the stove resume their process of gathering and/or purchasing cooking fuel should be noted and interviews should be conducted with these families several months out.

Some baseline Indoor Air Pollution (IAP) data was collected during the pilot study. The readings show high levels of IAP. More quantitative data would be helpful, both baseline and post intervention data. Baseline data was also taken at the Bonga Camp. Twenty stoves will go to the Bonga Camp to use for measuring IAP improvement with the use of the CC stove. IAP tests should also be conducted in the Kebrebeyah Camp.

The prototype stove used for the pilot study is a two-burner stove. This study clearly suggests that a one-burner stove would be more appropriate for camp use. The feasibility of producing a one-burner stove with some or all of the design elements suggested by this study should be considered.

Figure 6: Improved Injera and CC Stoves Used Side by Side.

Designing a CC stove to cook Injera should also be considered. Since Injera baking constitutes about 50% of the biomass fuels demand, developing an ethanol-powered Injera cooker would provide significant benefit. In the Shimelba Camp the Injera cooker continues to be used by families side by side with the CC stove because the CC stove cannot perform this all important cooking task.

6.1 Project Sustainability

Longer-term project sustainability should be investigated. The Gaia Association is now a UNHCR implementing partner and has entered into agreement with UNHCR to supply stoves and ethanol fuel to the camps with assistance from UNHCR (Sub-project No. 06/AB/ETH/LS/450(f)(fn)). UNHCR and Gaia Assoc. met with Finchaa Sugar Company and reached agreement on a supply contract of 300,000 liters for 2006, to be managed by Gaia Association. The price per liter is 2.15 ETB, which is the current gate price. A supply contract for 2007 should be obtained as soon as possible.

Long-term project sustainability can be determined in part by assessing ethanol fuel supply and cost into the future. It is known that FDRE has endorsed an ambitious expansion of ethanol fuel production capacity at Finchaa Sugar and new capacity to be developed at Metehara and Wonji sugar factories. Several private distilleries are also under study.

Policy discussions should be undertaken with the FDRE to ask for adequate amounts of this ethanol to be reserved for household energy use at a stable price kept low by exemption from taxes (similar to kerosene).

Study of efficient supply logistics of ethanol to Shimelba and Kebrebeyah camps should also be undertaken. Initial discussions with the World Bank Country Office indicate that the World Bank may be able to help with the cost of acquiring such infrastructure. It is recommended that UNHCR and Gaia Assoc. help to promulgate such a study.

Comparative costs of fuels should be evaluated against likely cost of ethanol. Many people in the camps purchase solid fuels. Price of these fuels should be documented. Prevailing prices for biomass fuels in the region should also be understood. These prices are rising.

The price of petroleum fuels is of course more easily understood. Current Addis/Dire Dawa retail price for kerosene is 3.00 ETB/liter with a direct government subsidy of 0.8797 ETB/liter and complete exemption from government excise, value added, road fund and municipality taxes. These taxes are charged on gasoline and amount to from 1.8 to 2.15 ETB. This includes a payment to the fuel price stabilization fund of up to almost 0.50 ETB for fuels ex-Sudan and 0.06 for fuels ex-Djibouti, whereas kerosene receives a payment from the stabilization fund of almost 0.88 ETB/liter. It is questionable whether the FDRE will be able to continue to subsidize kerosene to this extent. (These figures are from current published reports from the Ethiopian Petroleum Enterprise (EPE).)

LPG is not purchased and imported by the FDRE. Its price and supply in Ethiopia are unreliable. Although LPG can compete with other fuels in certain regional markets, generally LPG is expensive and in short supply on the world market.

Gaia Association is undertaking with UNDP assistance a business planning study with a private sector partner (Makobu Enterprises PLC) to develop a strategy for commercialization of an ethanol stove and fuel business in Ethiopia. The outcome of this study will help to determine long-term sustainability of an ethanol-based “Clean Energy/Safe Energy” project in the UNHCR camps.

7. Next Steps

Gaia Association is now a UNHCR implementing partner. As a result of the 2004-2005 pilot studies, there are currently 300 alcohol stoves operating in Shimelba Camp and Kebrebeyah Camp. At UNHCR's direction, Gaia Association will place at least 500 additional stoves into the refugee camp selected by UNHCR for scale up in 2006 and will support the UNHCR and its partners, ZOA and ARRA, with training, monitoring and reporting activities regarding stove use in the camps. UNHCR and Gaia Assoc. will jointly seek funds to place additional stoves and to supply ethanol in 2007.

The camp to be chosen for scale-up in 2006 will be the Kebrebeyah Camp in the east. The pilot study in the Kebrebeyah Camp yielded results similar to those of the Shimelba Camp, with the notable exception that fuelwood use reductions at Kebrebeyah approached 95% and even 100%. This is because the Somali style of Injera cooking requires a smaller plate, which readily fits on the CC burner and is small enough that the heat from the CC burner spreads evenly across the plate, yielding good results for Injera cooking. This enables the CC stove to become the sole means for cooking, with biomass fires for Injera cooking no longer required. This provides a striking advantage for focusing on Kebrebeyah Camp first, given that there are not sufficient resources to scale up in both camps at once or to scale up as quickly as might be desirable in either camp. Also it should be noted that biomass reserves are being rapidly depleted around Kebrebeyah Camp. A bigger impact can be made at Kebrebeyah more quickly with the limited resources currently available than at Shimelba.

Establishing an objective of supplying all families in Kebrebeyah Camp with an improved stove by the end of 2007 would be very worthwhile and may be achievable. To do this, additional partners who can fund the scale-up will have to be identified. An inquiry has already been made to the World Bank Country Office for assistance through its biofuels development program.

With scale-up in Kebrebeyah Camp achieved, attention could turn to the other camps, particularly Shimelba Camp. The problems with resource conflict at Shimelba Camp are increasing. It would be desirable to break this rising cycle of tension and violence. A new camp is planned for the Tigray region. It would be very desirable to have an energy program ready for each of these camps.

UNHCR and Gaia Assoc. should work with Dometic AB to see if it is possible to use a one-burner stove rather than the two-burner prototype for scale-up.

It will be important to create a "template" with the Kebrebeyah Camp for "Clean Energy/Safe Energy" programs in other refugee camps beyond Ethiopia and well as for emergency interventions that may be required around the world. Examples of such emergency interventions might include the October 2005 earthquake in Pakistan or the 2006 East African drought.

ATTACHMENTS:

Annex I: Safety of Ethanol Compared with Other Liquid Fuels

Annex II: Sample Evaluation Tools—Fuel Evaluation Grid, Stove Evaluation Grid and Livelihood Sustainability Grid

ANNEX I

Safety of Ethanol Compared with Other Liquid Fuels

	Ethanol	Gasoline	Kerosene	Diesel
Flammability & Fire Hazard Vapor Density Relative to Air: The denser the vapor, the more likely it will accumulate at lower levels of a room (near the floor) where ignition sources are commonly encountered. **A lower value is safer than a higher value.**	1.59	3.0 to 4.0	4.5 to 5.9	4.5
Flammability & Fire Hazard Heating Value (kBTU gal^{-1}): The amount of heat released during combustion, including radiated heat from the flames. **A lower value is safer than a higher value.**	Lower: 74 Upper: 85	Lower: 111 Upper: 122	Lower: 121 Upper: 130	Lower: 130
	When ethanol burns outside of a controlled environment like the stove chimney, it burns in excess air, which produces the typical "lazy" flame of a can of sterno. For this reason, an alcohol flame can often simply be blown out.	Gasoline and kerosene burn with enormous release of heat; much of this heat is radiated by the flames, making it difficult to approach the fire to extinguish it.		
Flammability & Fire Hazard Lower Flammability Limit: The minimum concentration at which a fuel will ignite. (Accidental fires often occur because flammable vapor increases from a low level to the LFL. **A high value for LFL is considered to be safer than a low LFL**.)	3.3%	1.3%	0.6 to 1.7%	0.5%
Flammability & Fire Hazard Miscibility in water	100% Miscible	Immiscible	Immiscible	Immiscible
	Flames extinguished by water	Flames will only be spread by water.		
Environmental Hazard Degradation in the Environment	Mixes readily with water and quickly degrades in the environment	Do not mix with water and do not degrade rapidly in the environment		
Toxicity: Threshold Limit Value for Exposure: The concentration of an airborne substance to which an average person can be repeatedly exposed without adverse effects. Expressed here in parts per million (ppm) **A higher value is safer than a lower value.**	1000	300 1ppm only for benzene	20 to 100 .01 to 25 for particulate matter in air	10 to 100 .01 to 25 for particulate matter in air

ANNEX II

EVALUATION GRID FOR PROVISION OF COOKING FUELS IN REFUGEE CAMPS WHERE BIOMASS IS STRESSED OR NOT AVAILABLE (BIOMASS MUST BE PURCHASED, IMPORTED OR IS GATHERED WITH DIFFULCULTY)

A. Fuel Evaluation Grid (fuel purchased)

Fuel Type	Handling/Shipping Ease & Efficiency	Score	Supply Sustainability	Score	Cost	Score	Safety Combustion	Score	Safety Emissions	Score	Score Subtotal
Purchased Biomass	Difficult, inefficient	1	Not sustainably harvested	2	Cheap to buy, expensive to ship	3	Open fire	2	Smoke, soot, CO heavy IAP	1	9
Charcoal	Can be packed; more Btus per wt. & volume than fuelwood	2	Not sustainably harvested; highly consumptive	1	Expensive; illegal or regulated by federal gov't	1	Charcoal is contained	4	Dangerous CO production	3	11
Kerosene	Efficient	5	Imported, available	4	Petroleum fuels prices are rising. Currency leaves Ethiopia to buy fuel	3	Explosions, flare ups and spills	1	Soot, odors, benzene and other VOCs	2	15
LPG	Efficient but cylinders are heavy & bulky & must be returned	4	Imported, much less available	3	LPG less available than kero and more expensive	1	Gas under pressure; gas leaks, explosions	3	Clean	5	16
Ethanol Fuel	Efficient but fewer Btus than kero	4	Manufactured domestically; industrial byproduct; more distilleries needed; federal government priority	4	Domestically produced; can undersell kero; currency stays in Ethiopia	5	No explosion or flare up hazard; extinguishable by water	5	Clean	5	23

B. Stove Evaluation Grid

Fuel Type	Stove Type	Stove Efficiency	Score	Stove Safety	Score	Stove Performance (Cook time)	Score	Stove Cost	Score	Stove Convenience	Score	Score Subtotal Stoves	**Total Score A&B**
Purchased Biomass	3-stone	8%	1	Somewhat dangerous	2	Variable with size and fuel	3	0	5	Inconvenient	1	12	**21**
	Improved	20%	2	Safer	3	Variable with size and fuel	4	50 birr	4	More convenient but requires fuel feeding	3	16	**25**
Charcoal	Lakech	25%	2	Safer	3	Medium	3	50 birr	4	Charcoal tending	3	15	**26**
Kerosene	China Wick	33%	3	Dangerous	1	Slow	1	50 birr	4	Convenient; wick & burner tending	3	12	**27**
LPG	1-burner with cylinder, hose & regulator	55%	5	Safer	4	Fastest	5	350 birr	1	Convenient	5	20	**36**
Ethanol Fuel	CleanCook 1-burner	61%	5	Safe	5	Fast	4	250 birr	2	Convenient	5	21	**44**

Summary of Findings: When the Business as Usual Approach (reliance of biomass fuels—whether gathered or imported) is reconsidered in light of other factors, including fuel emissions, fuel safety, stove safety, stove performance, and macro economic considerations such as buying a sustainable and domestically produced fuel (not imported), an evaluation of all considerations shows that the improved fuel stoves emerge as the preferred alternatives and the alcohol-powered CleanCook stove emerges as the preferred among these by a scoring margin of 18%, with LPG second.

Scores have been assigned in each evaluation area on a 1 to 5 scale, with 5 best and 1 least good. Each score column may be assigned a weighting value. For example, scores on cleanliness and safety might be weighted more heavily than other scores, or scores on fuel cost and stove cost could be weighted most heavily. This grid analysis demonstrates a simple stove-fuel ranking methodology that attempts to reflect and factor hidden costs as part of a comprehensive evaluation.

C. Livelihood Sustainability Evaluation Grid (Additional Issues Considered)

Fuel Type	Fuel Score A (above)	Stove Score B (above)	Total A&B	Cash Cost of Fuel		Burden of Collection/ Distribution		Health & Safety in Acquisition		Environmental Impact at Camp		Camp Management Issues		Total Score A,B&C
Gathered Biomass	9	12	21	Not purchased	2	Heavy loads, long distances	1	Accidental injury; injury from conflict, rape, reprisal	1	Resource intensive	2	Enmity with host community; human costs; medical and remedial costs	1	28
Purchased Biomass	9	12/16	21/25	Already in fuel score		Sorting, handling	4		5	Essentially same impact as above	2	Storing, handling	4	36/40
Locally Made Charcoal	11	15	26	Not purchased	4	Same as Gathered Biomass, plus manufacture	1	Accidental injury; injury from conflict, rape, reprisal	1	Most resource intensive; 85% energy loss in manufacture	1	Enmity with host community; human costs; medical and remedial costs	1	34
Purchased Charcoal	11	15	26	Already in fuel score		Sorting, handling	4		5	Essentially same impact as above	1	Storing, handling	4	40
Kerosene	15	12	27	Already in fuel score		Least handling	5		5		5	Easiest storage and handling	5	47
LPG	16	20	36	Already in fuel score		Least handling	5		5		5	Easiest storage and handling	5	56
Ethanol Fuel	23	21	44	Already in fuel score		Least handling	5		5		5	Easiest storage and handling	5	64

This grid seeks to take the stove and fuel analysis further by quantifying the benefits and detriments of fuel gathering. The two types of gathered fuel considered are fuelwood and fuelwood for charcoal manufacture. The gathered fuel options rank well below any purchased fuel option.