FUEL-EFFICIENT STOVE PROGRAMS IN IDP SETTINGS

SUMMARY EVALUATION REPORT DARFUR, SUDAN

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Acronyms

CCT	Controlled Cooking Test
FES	Fuel-Efficient Stoves
IDP	Internally Displaced Persons
NGO	Non-Government Organization
OCHA	Office for the Coordination of Humanitarian Affairs (United Nations)
OFDA	Office of Foreign Disaster Assistance (USAID)
SDG	Sudanese Pound (SDG 2 = $1 USD at time of field study, April 2008)
TOT	Training of Trainers
UNAMID	United Nations – African Union Mission in Darfur
UNJLC	United Nations Joint Logistics Center
USAID	United States Agency for International Development
WBT	Water Boiling Test

1. INTRODUCTION: EVALUATION OBJECTIVES

Around the world, conflict and natural disasters have displaced millions of people. Displaced populations fleeing to settlement camps and seeking safety in host villages often put great stress on natural resources, leading to environmental degradation and conflict with local populations. One of the greatest needs of people affected by crisis, be they displaced, settled, or on the move, is firewood or some other type of fuel to cook their food, heat their homes, and treat water for drinking and food preparation. The risks endured (especially by women and children) collecting scarce wood resources constitute some of the most challenging and serious protection concerns both in IDP camps and in villages where conflict over resources is high.

USAID's Office of Foreign Disaster Assistance (OFDA) has been one of the key US Government entities providing funding for humanitarian organizations implementing fuel-efficient stove (FES) programs in populations of internally displaced persons (IDPs). The FES programs are intended to help accomplish various goals, such as improved food security or decreased deforestation, by reducing fuel consumption. However, the large number of implementers, their varying program objectives and degrees of expertise, and differing conditions within and among IDP communities have made it difficult for OFDA to determine the relative efficacy of the FES interventions and provide guidelines for USAID-funded institutions working in IDP settings.

OFDA therefore enlisted the assistance of the USAID Energy Team to undertake a multi-phase evaluation in order to derive "best practices" for future FES interventions. While the primary purpose of this evaluation is to provide guidance to USAID-funded organizations, USAID hopes to inform the broader humanitarian community by sharing the results of the evaluation with other organizations. Eventually, the best practices will be developed into a series of recommendations and toolkits for use by NGOs, donors, and other groups operating FES programs in IDP settings.

Phase I of the evaluation (November 2006) was a desk study of recent FES projects in refugee and IDP settings. Based on the desk study findings, Phase II (December 2006) entailed the development of a methodology for conducting the evaluation fieldwork. Phase III involved on-site research in IDP camps in Northern Uganda and in Darfur. The Northern Uganda report has been completed and is available on USAID's web site.[1] Phase IV will entail the development of recommendations and tools to improve FES programs.

The Phase III field research in Darfur took place in two phases. First, a four-day review and training on the evaluation methodology and tools was held in Khartoum in March 2008 with the assessment team. The fieldwork in Darfur IDP camps took place from 16 April to 9 May 2008, with a six-person all-Sudanese team composed of technical stove experts and social scientists. Three OFDA-funded NGO FES programs, one in each region of Darfur, were selected for assessment. However, due to continued security concerns and the difficult logistics of deploying a team of investigators into Darfur, it was possible to include only two regions in the assessment. This report summarizes findings regarding programs being implemented by two organizations in Otash Camp in Nyala, South Darfur, and one organization in Kabkabiya near El Fasher, North Darfur. The implementing NGOs are not named in this report and are identified only as NGO A, B, and C.

[1] www.usaid.gov/our_work/economic_growth_and_trade/energy/publications/EGAT0020.PDF

The evaluation methodology incorporated a number of different tools to collect both quantitative and qualitative data on the FES programs. The underlying objectives were to determine 1) if the FES interventions were meeting their fuel saving goals, and 2) why or why not. Specific areas examined included:

- cooking technologies
- user outreach and education programs
- stove production and dissemination strategies
- FES project monitoring and evaluation (M&E) frameworks

In total, the field team conducted 150 household energy surveys, 66 controlled cooking tests, and 50 water boiling tests, as well as camp and programmatic surveys, focus group discussions, and informal participant observation and interviews. This summary report consolidates the findings from the three Darfur program evaluations and presents OFDA with preliminary recommendations designed to improve the impact and quality of its future support to FES activities in IDP situations. Final recommendations and guidance from “lessons learned” will be developed from the findings of both the Darfur and Northern Uganda assessments.

2. EXECUTIVE SUMMARY

Darfur, the westernmost region of Sudan, has been embroiled since 2003 in violent conflict that has resulted in the internal displacement of over 2 million people, many of whom are living in temporary camps. USAID's Office of Foreign Disaster Assistance (OFDA) has been one of the key US Government entities providing funding for humanitarian organizations working in Darfur. One component of humanitarian relief for the region's internally displaced persons (IDPs) has been the introduction and promotion of fuel-efficient stove (FES) programs. An increasing number of humanitarian organizations are requesting funds to implement these programs throughout Darfur.

FES can deliver numerous benefits to end-user households, including fuel and time savings, reduced exposure to smoke, and lessened risks of fires and burns. Programs promoting FES therefore seem well-suited to IDP settings, where such multi-sectoral benefits typically are urgently needed but difficult to achieve given staff and resource constraints and difficult logistical conditions. To better understand FES program drivers and outcomes, the USAID evaluation in Darfur examined four types of FES being promoted by three different non-governmental organizations (NGOs), to ascertain whether the stoves were indeed reducing fuel consumption. In addition, the evaluation team sought to identify behavioral and programmatic factors that influenced the likelihood that the FES programs would meet their fuel savings and other goals. The evaluation revealed a considerable range in stove performance and implementation strategies. Given the small sample set, the data should not be considered definitive, but rather as indicators of areas where improvements can be made. Key findings of the evaluation include:

- Darfur is one of the world's most challenging places to undertake humanitarian assistance. Field staff work in dangerous conditions, turnover is high, logistics are challenging, and access to the camps can be difficult to obtain. Despite these obstacles, all of the NGOs whose programs were reviewed had succeeded in disseminating stoves to large numbers of camp residents.
- Stove performance tests conducted by the evaluation team revealed that one stove seemed consistently to consume significantly less fuel than the traditional three-stone fire; several performed slightly better or worse than the three-stone fire; and one stove consistently consumed more fuel than the three-stone fire. Fuel efficiency did not increase proportionately with the cost/design sophistication of the stoves tested.
- The NGO programs reviewed did not incorporate sufficient monitoring and evaluation systems to guide their performance or validate their results. When data was collected, it was not disseminated adequately throughout the organization or the surrounding community.
- Several of the NGOs had sought outside expertise to introduce new stove models and strengthen their FES programs. However, promotion/dissemination of multiple technologies stretched the management capacity of the programs.
- NGOs need to spend more time on end-user education, to ensure that behavior change messages are transmitted effectively and that beneficiaries know how to use their stoves to obtain maximum benefits.
- Beneficiaries typically were enthusiastic about their stoves. However, many stated that they experienced difficulty maintaining the stoves, particularly after donor support had ended.

Focus group discussions and one-on-one interviews revealed that IDPs in Darfur are very interested in new cooking technologies, and especially welcome benefits that improve their overall quality of life (such as reductions in the incidence of fires and burns). The evaluation team concluded that the promotion of FES remains a valid intervention for humanitarian assistance programs, but recommends that donors and implementers strive for realistic, consistently attainable fuel efficiency performance. This will require the following steps:

- Stronger monitoring and evaluation protocols that will need to be implemented throughout the life of the program (not just at the beginning and end). The monitoring and evaluation criteria should incorporate a variety of both qualitative and quantitative data collection methods, in order to identify and address discrepancies between end-user feedback and stove performance tests.
- Workshop-centered production utilizing paid specialists, in order to improve quality control and maintain stove design parameters.
- Regular training for beneficiaries on how to maintain their stoves (particularly mudstoves, which crack with time), along with safe access to materials needed for repair.

In addition, the introduction of market-based principles into the stove production and distribution process should be explored. For instance, charging a minimal amount for each stove might help improve the quality of the stoves (and the sustainability of the programs) by giving end-users a vested interest in their stoves' performance and creating mini-markets for various stove services (i.e., repairs). This can be achieved, however, only if all NGOs working in a given area adopt the same strategy, which will require greater planning and coordination at the camp level.

3. DARFUR

3.1 INTRODUCTION

The conflict in Darfur began in April 2003 and has forced about 2.5 million persons, approximately one-third of the regional population, to abandon their homes and settle in large camps for displaced persons. Table 3.1 shows the distribution of the affected population across the three states of Darfur. Many of the camps, as seen in the map in Annex A, are located around major cities and towns. After five years of conflict many camps continue to see new arrivals. Moreover, sexual and physical assaults on camp residents continue to be reported on a daily basis. The lack of security has greatly worsened the already meager livelihoods of the affected populations.

Table 3.1: War-Affected Population In Darfur, early 2008

State	Total affected	IDPs	Residents
Northern Darfur	1,340,869	521,012	819,857
Southern Darfur	1,628,275	1,185,012	443,263
Western Darfur	1,301,235	745,952	555,283
Total	4,270,379	2,451,976	1,818,403

Source: OCHA; *Darfur Humanitarian Profile* No. 30 – January 2008

The effort to assist the population of Darfur affected by the war has become one of the world's largest humanitarian relief operations. The humanitarian operations involve provision of food, nutrition, shelter, clean water, sanitation, health care, education, protection, and income-generating activities. The working environment in Darfur is extremely volatile and dangerous, and is one of the most challenging to operate in anywhere in the world. Virtually all aspects of the humanitarian response are difficult, demanding, and frustrating, from setting up a program and obtaining employees, to securing work, travel, and site permits and maintaining productive working relationships with local and national authorities. While the findings in this report are mixed in terms of FES performance in the two camps, the humanitarian organizations working in those camps and throughout Darfur are to be highly commended for their efforts to reduce security risks and environmental degradation through the introduction of FES.

The average household size in the camps, according to the household survey results, is about 6 persons per household. The average age of male heads of household is between 40-45 years, and female-headed households are slightly younger. About half of male household heads claim they can read and write in Arabic, but very few female household heads or primary cooks (all female) read or write in Arabic.

Table 3.2: Characteristics Of Households Surveyed In Darfur IDP Camps

	n=	Mean age of household head	Mean age of primary cook	Average number of persons in household	Percent of household heads who write Arabic	Percent of primary cooks who write Arabic
Kabkabiya, female household head	14	38.6	37.2	4.4	0%	7%
Kabkabiya, male household head	37	40.0	30.3	6.8	59%	35%
Otash, female household head	22	38.2	34.2	5.8	18%	23%
Otash, male household head	77	45.6	31.5	6.7	49%	23%
Combined	150	42.5	32.2	6.4	43%	25%

3.2 CAMP SITUATION

3.2.1 OTASH CAMP

Otash IDP Camp is a part of Nyala city municipality in South Darfur and is located about 5 km from the center of the city. Otash Camp has experienced a steady stream of new arrivals since it was established in October 2004. The population in early 2008 for Otash Camp was 63,307 persons. The majority of IDPs are from the Fur, Zaghawa, Berti, and Birgit tribes. Before the conflict, they lived in the northern and eastern parts of Southern Darfur state.

At the time of the assessment, there were at least 12 NGOs, both international and local, providing humanitarian services in Otash Camp. Camp management and coordination is the responsibility of a local NGO. However, community leaders (traditional leaders such as *omdas* and *sheikhs*) have assumed considerable responsibility for camp management in close coordination with the camp coordinator. The community leaders assist in food distribution, security, and cooperation with NGOs in the implementation of their humanitarian interventions.

Houses in Otash IDP Camp have been built from a variety of building materials (including plastic sheeting, mats, grass, and millet stalks) and have various shapes. Houses are very close together, but each family has its own homestead, or *hosh*, a demarcated area around the living quarters with a fence made from millet stalks or plastic sheeting. Generally, there are at least two structures, where females and males stay separately. Most households have a separate room or enclosure for the kitchen. Some households do not have a kitchen and cook outdoors. During the summer period, cooking is often done outdoors. The kitchen is often very well ventilated and shaded by a thatched straw roof (a *rakuba*). Although most houses retain their makeshift nature, after five years some IDPs have started building their houses with more permanent materials, particularly mud bricks. Photo 3.1a is a Google Earth image of one part of the camp, showing how close together living structures are. Photo 3.1b shows a typical living structure.

Photo 3.1a Google Earth image of part of Otash Camp

3.1b: Typical house construction in Otash Camp

3.2.2 KABKABIYA

Kabkabiya is located approximately 150 km west of El Fasher in North Darfur. In Kabkabiya, displaced persons have settled in the town itself and are co-mingled with town residents. There is no delimited camp established for the displaced persons. Some IDPs have lodged with their kin, others have built makeshift houses on the streets, and some have settled near the town periphery. The reported population in early 2008 was 53,307 IDPs and 16,101 original town residents. The majority of IDPs in Kabkabiya are Fur ethnicity. Displaced persons from other tribes, like Zaghawa, are present in the town, but in far fewer numbers compared to Fur. The IDPs are mainly displaced from areas around Kabkabiya town and the Jebel Si area, while others come from Dar Zaghawa, far to the north.

Since there is no delimited camp, the administration of IDPs is based largely on traditional leaders (*omdas* and *sheikhs*). The IDPs have settled according to their places of origin, which facilitates this administration. The traditional leaders have assumed considerable responsibility for camp management in close coordination with the local authorities. They have assisted in

food distribution, security, and cooperation with NGOs in the implementation of their humanitarian interventions.

Photo 3.2 offers a Google Earth image of the outskirts of Kabkabiya town. IDPs in Kabkabiya have built their initial shelters using a variety of building materials (plastic sheets, grass, and millet stalks). Many IDPs have started rebuilding their houses using more permanent materials.

Photo 3.2: Google Earth image of Kabkabiya, outskirts of town

3.3 LIVELIHOODS

Since Otash Camp is located on the outskirts of Nyala city, IDPs have opportunities to participate in the local labor market. Some are employed as porters and transporters with donkey carts, and others are involved in the firewood trade. Some IDPs, especially young men, benefit from vocational training provided by humanitarian NGOs. Some of the trained youths, including metal workers and carpenters, have established small businesses within NGO-sponsored youth centers. They make use of grants or revolving funds established by the NGOs. Other male IDPs who have completed vocational training courses have found jobs in the Nyala market. Employment opportunities for women in Otash Camp include selling prepared foods; providing casual labor for brick-making, construction and housework in Nyala; and trade. A female laborer in Nyala reportedly is able to earn about SDG 8/US$4 per day.

IDP women in the Kabkabiya area are sometimes employed by the brick-making and construction industries, and they also carry out petty trade such as food selling and firewood collection. Some NGOs have implemented livelihood programs that target women. Besides providing training in business management, NGOs have established revolving funds for women who are interested in establishing small businesses. Producing handicrafts for sale, particularly *bertal* (food covers made of straw), is an important income-generating activity for women. The evaluation team also came across a group of women who specialize in leather tanning. Employment opportunities for the male IDPs in Kabkabiya include trading, gardening, and brick-making.

3.4 FOOD AND COOKING PRACTICES

Women are the primary cooks in Darfur, and the staple meal is *asida* with *mulaah*. *Mulaah* refers to the variety of sauces or stews that are served over the *asida*. Cooking *asida* involves bringing water to a boil and then vigorously stirring in flour and cooking over the fire to make a

stiff porridge or polenta-like mass. Cooking time is at least 30-40 minutes for an experienced cook using a wood-burning stove. The *mulaah* sauces/stews typically require close attention by the cook as ingredients are added and stirred step-by-step. Cooking onions is a major part of the preparation of most sauces. The simmering phase generally takes at least 15-20 minutes.

The sizes of the round aluminum pots commonly used by households in Darfur IDP camps vary from 16cm to 28cm in diameter. Virtually every household has at least two pots of different sizes. The smaller one is used for making *mulaah*, while the larger one is used for cooking *asida*.

Most households interviewed in the household survey claimed to be familiar with various cooking practices that are promoted as being energy-efficient. These include:

- drying wood before using it as fuel
- cutting fuelwood into smaller pieces to better manage fuel consumption
- covering the pot with a lid when cooking
- adding soda ash (*kombo*) or *maggi* cubes to help speed cooking
- soaking beans before cooking
- banking a fire after use to preserve fuel.

4. EVALUATION APPROACH

The following seven tools were developed or adapted for the evaluation of the FES programs:

Type of Tool	Description	Purpose
Contextual	Camp Survey	To gather background information on the camps and the regional and local situation (environmental, institutional, socio-economic, security, etc.)
	Programmatic Survey	To gather information on the NGOs and the specific details of their FES programs (justification, objectives, activities, indicators, monitoring and evaluation systems, resources, etc.)
Quantitative	Water Boiling Tests	To provide technical data on the performance of stoves in the camps
	Controlled Cooking Tests	
	Household Energy Survey	To provide statistical information and gauge attitudes of the FES programs' beneficiaries: 99 in Otash Camp and 51 in Kabkabiya. The team attempted to ensure a random sampling, but security issues in the camps meant that camp leaders had some influence over who was available for interviews
Qualitative	Focus Group Discussions	To provide supplementary data to complement the household survey findings and cooking tests, and investigate interesting issues in greater depth
	Opportunistic Participant Observation/Interviews	To gather anecdotal information, make informal observations and seek confirmation of the findings of the household survey, cooking tests, and focus group discussions

5. HOUSEHOLD ENERGY

5.1 FUELWOOD SITUATION IN IDP CAMPS

The main source of energy for IDP cooking purposes in Otash and Kabkabiya is firewood. In the absence of organized distribution of cooking fuel, early residents of the camps resorted to collecting firewood in the camp vicinity. There were two serious consequences. First, in the fragile ecosystem of Darfur, a region characterized by low rainfall and recurrent drought, the need for firewood led to rapid deforestation around the camps. This deforestation may result in permanent land degradation. Second, as deforestation advanced, women and girls, the primary family members responsible for collecting fuelwood, were obligated to walk ever greater distances in search of trees (or even tree roots). This exposed them to the possibility of sexual assault by roaming gangs of soldiers, militias, and bandits. Men who venture out of the camps to cut wood or make charcoal for sale are also vulnerable to attack.

At the time of the IDPs arrival to Kabkabiya, the natural resource situation around the camp, particularly tree cover, was fairly good. However, as the IDPs were denied access to firewood collection far away from the town because of security concerns, they resorted to cutting green trees and shrubs, which they dried and used as fuel for cooking. After five years of displacement, the area around Kabkabiya has been largely denuded of tree and shrub cover. Some residents are digging out roots of trees to use for fuel. Otash Camp is located at the periphery of Nyala city, so the natural resource situation was very poor to begin with, as tree cover had already been largely cut down.

The scarcity of fuelwood and dangers of firewood collection leave many households dependent on firewood markets in the camp areas, where traders deliver firewood and retailers get their supplies for resale in different parts of the camp.[2] Firewood is sold in bundles of different weights. In Otash, the price in April 2008 was approximately SDG 2 (US$1) for 8 kg of wood. In Kabkabiya, wood was somewhat less expensive, and for SDG 2 (US$1) one could obtain about 9.5 kg of wood. Residents of both camps also use charcoal, especially for making tea and coffee. The fuelwood markets sell charcoal, and households save the charcoal residues of their wood fires for cooking.

Results from the household survey suggest that families in Otash spend about SDG 10 (US$5) per week on fuelwood, using approximately 40 kg of fuelwood (see table B2 in Annex B). This corresponds to the results of the controlled cooking trials, which suggest that households use about 2 kg of fuelwood per meal, so 40 kg would be enough for 20 meals during the week. Expenditures in Kabkabiya were slightly lower. About half of the households in Otash also reported purchasing charcoal, spending about 10 SDG (US $5) per week. Very few households in Kabkabiya reported purchasing charcoal.

Some IDPs are involved in providing firewood or making charcoal for commercial purposes. These income-earning activities can be dangerous. In Otash Camp, a small group of men might leave the camp for about 10 days to gather firewood about 65 km outside Nyala. During the time that they are away from the camp, they are in considerable danger of harassment by armed persons living in the area. Once the wood is collected, one person stays behind to guard the

[2] It should be noted that brick-making is another major source of demand for fuelwood, as bricks are fired in kilns that use fuelwood. The team did not have time to quantify the extent of demand for fuelwood by this sector.

load and the others return to Nyala to hire a truck and porters to load and transport the wood. The standard rate for a truck is SDG 225/US$112.50 plus four jerry cans of diesel fuel. Very often, fees for forest entry permit are paid to armed individuals who claim to own the forested area. Other payments are also demanded at different check points along the road.

Some women go outside of Otash Camp on their own to fetch firewood and *dom* leaves. A large group of women, sometimes as many as 50, might hire a truck for SDG 300/US$150 per day to transport the wood that is collected. Each of the women pays SDG 6/US$3 to the truck owner/driver. The truck leaves the camp very early in the morning and returns before sunset. Each woman collects as much firewood and *dom* leaves as she can during that period. The wood collected typically is used for family consumption, while the *dom* leaves are mainly for the market or for weaving mats for sale.

In Kabkabiya, it is more likely that a group of male IDPs with donkey carts would go out for about three days to gather wood at a distance of about 30-40 km south of the city. During these three days, they can be subjected to considerable harassment from armed gangs. As with Otash residents, they often must pay for forest entry permits to armed persons who claim to own the forest, as well as fees to guards at various check points along the road. The value of a donkey cart load of wood is around SDG 40/US$20. Women also sometimes venture out to collect wood.

The United Nations – African Union Mission in Darfur (UNAMID) peacekeeping forces provide patrols for the women for firewood collection. However, the women interviewed by the assessment team were dissatisfied that the protection service is only available once every two weeks. Commercial firewood collectors and traders also claimed that the UNAMID protection services were not regular enough and that armed groups in the forest might detain or punish fuelwood collectors on the days when UNAMID was not accompanying them.

5.2 TRADITIONAL COOKSTOVE DESIGN

Cookstoves generally fall into two categories: traditional and “improved” (with the latter typically referring to more fuel-efficient stoves). Traditional stoves tend to be made of locally obtained materials such as stones or stones plus clay soil. Typically they are non-portable and built in situ by the user, who generally has little or no training in stove design and production.

The dominant traditional cooking technology in developing countries is the “three-stone fire.” This is one of the simplest cooking methods and is highly adaptable as it can utilize many types of fuel (i.e., firewood, crop residues, dung, leaves) and any type or size of cooking pot (metal or clay, flat- or round-bottomed). The three-stone fire consists of a cooking pot resting upon three stones or bricks that surround an open flame. It is free to build, simple to use, and can serve various non-cooking functions (such as providing a social gathering point). However, depending upon the cook’s skill, the three-stone fire may require a lot of fuel, generate a lot of smoke, and present considerable safety risks from fires or burns. These are serious concerns in IDP situations, where fuelwood is expensive relative to the very low incomes, respiratory illness is common, and living quarters are both cramped and highly flammable.

Most households in Darfur and in Sudan cook with both wood and charcoal. Many camp households use the traditional three-stone fire known locally as a *ladaya*, with all the attributes, both positive and negative, of this type of stove (see Photo 5.1).

Photo 5.1: Three-stone fire, known as a ladaya

For burning charcoal, many households use either a traditional metal stove or the *mubkhar* stove (see Photo 5.2). The *mubkhar* charcoal stove (sometimes known as the *azza* stove or the *al-sorour* stove) was developed in central Sudan in the 1980s. By 2008, use of the *mubkhar* charcoal stove had spread throughout Sudan. Made from clay and animal dung, the *mubkhar* is relatively efficient and inexpensive, with the price ranging between SDG 1 and 3 (US$0.50 and $1.50). Its lifespan, however, often is very short because the stove is fragile and vulnerable to degradation from water, especially when the water is hot. Charcoal typically is a secondary fuel for cooking, and either is bought from the market or made from embers that remain after cooking with wood stoves. Charcoal is used mainly for preparing quick meals or beverages, such as tea and coffee.

Photo 5.2: Mubkhar stove

Respondents in the household survey were asked about their likes and dislikes concerning the three-stone fire, and the responses are shown in Table 5.1. A vast majority of respondents thought that the three-stone fire used a lot of wood to cook a meal. Many respondents noted that it was a dangerous way to cook because the open flame could burn household members, especially children, and could cause fires in the straw huts that many households use as living quarters.

Table 5.1: Likes And Dislikes Of Traditional Three-Stone Fire (*ladaya*)

	Percent of respondents mentioning characteristics	
	Otash	**Kabkabiya**
Likes	**n=30**	**n=13**
Traditional	10%	31%
Cheap	17%	8%
Simple	17%	62%
Better	17%	15%
Ignites easily	13%	23%
Fits all pot sizes	7%	31%
Don't know any other	3%	0%
Other	47%	31%
Dislikes	**n=47**	**n=31**
Dirty	21%	48%
Lots of smoke	19%	42%
Dangerous (causes burns)	43%	32%
Uses lots of wood	72%	94%
Could cause a house fire	34%	29%
Other	11%	3%

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages rounded to the nearest whole number.

5.3 IMPROVED STOVE TECHNOLOGIES

Fuel-efficient stoves are usually made with more sophisticated materials such as metal, fired bricks, or combinations of clay soil plus straw, cow dung, sawdust, or rice husks to improve insulation and durability. FES are often portable and some designs incorporate features for smoke removal. Some have complex design features and must be made by specialists, while others can be built by end-users themselves with appropriate training. Regardless of who makes the stove or where it is produced, users generally will need guidance to operate an FES properly and obtain the maximum benefits possible.

The evaluation team examined four improved stove programs for this study: (1) a simple mudstove, (2) an improved mudstove known as the AVI3, (3) a six-brick Rocket stove, and (4) a metal stove known as the Tara stove.

The mudstove disseminated by NGO A (see Photo 5.3) is a version of the mudstove originally promoted by Practical Action and the United Nations Joint Logistics Center (UNJLC). The mudstove has a simple design and can be built by camp women after a short training course. The stove is made of locally available, inexpensive materials (clay and animal dung), and its size can be directly tailored to pot dimension. Mudstoves of the same basic design have been tested in refugee camps in other places in the world.[3] Some studies have found the energy

[3] UNCHR, Refugee Operations and Environmental Management, *A Handbook of Selected Lessons Learned from the Field*, 2002.

savings of the improved mudstove over the three-stone fire to be at least 30% to 40%, if the stove is built correctly.[4]

Photo 5.3: Mudstove, NGO A

The FES programs of NGO B promote two stove designs that they consider to be superior to the *ladaya* and simple mudstove: a redesigned mudstove[5] known as the AVI3 (Photo 5.4); and the metal Tara stove (Photo 5.5). The AVI3 includes a fire grate and primary air intake holes. Like the simpler mudstove from which it is derived, it can be made easily by camp residents after some training, and the required materials are available locally.

Photo 5.4: AVI3 stove, NGO B

Photo 5.5: Tara stove, NGO B

In Kabkabiya, NGO C promoted two stove designs that it considered superior to the *ladaya*: the same mudstove that was promoted by NGO A in Otash Camp, and the six-brick stove. The six-brick or six brick "Rocket" stove (see Photo 5.6) was introduced by NGO C in 2007.

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[4] Stephen Gitonga, "Energy Options for Refugee Camps," *Boiling Point* Issue 37, 1996.

[5] In ordinary usage, the words "mud "and "clay" have the same meaning in Arabic (*teen*). Although the AVI stove is built of clay, since it is unfired, it will be referred to as a mudstove in this report.

Photo 5.6: Six-brick stove, NGO C

5.4 FES PROGRAMS IN DARFUR

5.4.1 NGO A's FES PROGRAM

NGO A started FES activities in Otash and a number of other IDP camps in South Darfur in late 2004, and completed its stove activities in July 2007. During this period, NGO A reportedly distributed 16,000 FES: 2,600 of these were disseminated in Otash Camp, and another 800 were sold in the local market. The FES project was implemented within a wider program targeted at "Child Care and Gender Development." The dissemination of FES served the protection objective of the program, as well as environmental conservation. The evaluation team was unable to meet with any field staff that had worked on project implementation, and was unable to obtain any documents concerning the FES program from the current field staff. Program indicators included the number of women trained and the number of stoves built and taken home.

NGO A adopted a "training-of-trainers" (TOT) approach to stove production and dissemination. It organized its first training course in cooperation with a local NGO in Nyala. Six of the women trained showed excellent skills in building the mudstoves, and were subsequently appointed by NGO A as paid trainers. They in turn trained groups of 50 women how to make the stove at NGO A's production center. NGO A procured the materials to construct the stoves, mainly clay and animal dung. Other than labor, there was no cost to participants to obtain a stove. At the end of the program, NGO A tried to ensure the sustainability of the intervention by encouraging women to adopt stove building as a private income-generating activity.

Photo 5.7: Women examining NGO A's mudstove

With some assistance from NGO A, 13 women established their own mudstove production businesses. The mudstove price within the camp ranged between SDG 2/US$1 and SDG 4/US$2, depending on the size pot the stove could accommodate. The women also found a good market for the stove in Nyala, where the stoves could be sold for between SDG 4/US$2 and SDG 5/US$2.50. According to NGO A's monitoring reports, the 13 private mudstove producers were able to produce and sell about 800 mudstoves. The evaluation team was able to interview some of these stove entrepreneurs, but by the time of the evaluation there was no longer any ongoing stove production. The private mudstove producers had discontinued their stove production businesses largely due to competition from the AVI3 stove, which was being freely distributed by NGO B in Otash.

At the time of the evaluation, there were still many women using the mudstove in Otash Camp, but the team observed that most of the stoves had deteriorated over time. Although many women were trained in mudstove building, few appeared willing to re-build their deteriorated mudstoves. When asked why they weren't repairing their stoves, they claimed that NGO A was no longer providing the raw materials, which were expensive and could only be found far away from the camp. Other women said they preferred to get a new stove for free from the other NGO.

5.4.2 NGO B's FES PROGRAM

NGO B has been implementing FES activities since 2004 in Otash and a number of other IDP camps in South and North Darfur. The evaluation team assessed the two FES programs being implemented in Otash Camp, the AVI3 and the Tara stove programs. The FES program is part of a broader livelihoods program, and also is considered a vital activity for the prevention of gender-based violence. Indicators listed by the NGO to measure performance of the FES include: efficiency tests; production quality control; number of users of FES; and fuel use. According to information gathered from NGO B, by the end of 2007 approximately 9,640 improved mudstoves had been distributed to IDP women by its programs in both North and South Darfur. At the time of the assessment, 4,500 mudstoves from the Nyala workshop had been distributed.

NGO B modified the mudstove design previously promoted by NGO A by introducing a metal grate and two primary air entry holes at the bottom of the stove, which is known as the AVI3

stove. NGO B, which enlisted outside help to develop the new design, believes that these improvements make the AVI3 more efficient than the original mudstove. However, these changes make the stove perhaps 50% heavier than the original stove design, with finished stoves weighing approximately 30 kg.

NGO B found that the women producing AVI stoves did not always maintain recommended stove dimensions, with negative consequences in terms of firewood consumption and smoke emissions. The NGO tried to improve quality control by promoting a more careful and organized production process. NGO B established an AVI3 production facility in one of the women's centers in the camp, and provides the raw materials, mainly clay and biomass additive, for the trained stove builders to produce the stoves. The stove producers use molds to try to preserve stove dimensions. The stove producers are paid SDG 2 (US$1.00) per stove, and each stove builder produces only two stoves per day. Production is limited to promote careful work and attention to stove quality as well as to allow women to devote time to other chores. The stove production facility provides employment opportunities to about 35 women at a time. Only the supervisors and inspectors are regular full-time employees.

The production cost for the AVI3 stove is estimated to be around SDG 5 (US$2.50) per stove. At the time of the assessment, the AVI3 production facility at Otash Camp was producing about 400 stoves per week, working six days a week. The stoves are freely distributed to IDP households in Otash Camp at weekly gatherings at NGO B's women's center. Women are selected to receive stoves by the traditional camp leaders, *sheiks*, assisted by women animators[6], who are usually volunteers.

Toward the end of 2005, NGO B collaborated with engineers and students from the United States to develop an all-metal cook stove, known as the Tara stove. The design process involved laboratory and field work, demonstrations, household participation, and acceptance tests. During the first half of 2007, NGO B worked on establishing a production facility in Nyala. The workshop employs seven men (four technicians and three assistants) in addition to an engineer and a manager. Production started in July 2007. As of April 2008, 4,500 Tara stoves had been distributed. The capacity of the workshop was about 840 stoves per month in early 2008, but could be increased with better quality machinery, particularly the spot-welding machine.

The Tara stove costs approximately SDG 40/US$20 to produce. The cast iron grate is the most expensive component of the stove, costing SDG 24/US$12. In contrast to the free distribution of AVI3 stoves within the camp, NGO B opted to market the Tara stove through three sales channels:

- Subsidized sales at a price of SDG 10/US$5, targeting IDPs in camps around Nyala;
- Subsidized sales at a price of SDG 15/US$7.50, targeting IDPs and host communities in the rural areas of South Darfur, where NGO B has humanitarian programs; and
- Full cost price of SDG 40/US$20 for NGOs operating in areas where NGO B has no presence.

The team did not encounter any Tara stove sales activity in Otash Camp, nor in any sales outlets in the Nyala market. NGO B staff said that they were marketing the stove in Kas and El Fasher IDP camps. Staff observed that at the time of the evaluation in April 2008, the demand for the Tara stove exceeded production and therefore there was no surplus for sale in the Nyala

[6] Stove promoters.

market. NGO B seemed to prefer the third marketing option, where full cost recovery permits continuous production of the Tara stove. However, this option relies upon demand from NGOs; if their budgets for FES distribution diminish or end, it is not clear whether local demand would be sufficient to make production of the comparatively expensive Tara stove sustainable.

5.4.3 NGO C's FES PROGRAM

Under its emergency interventions, NGO C started dissemination of mudstoves in Kabkabiya and Saraf Omra in February 2005, and continued until June 2006. The FES activities fell under a broader food security program. NGO C sent three mudstove trainers to attend a TOT session organized by other NGOs in El Fasher in December 2004. These trainers subsequently organized training sessions in Kabkabiya, and established 10 stove centers in Kabkabiya town. Each center had five trainers to train women on stove building. Community committees were responsible for selecting women to attend the mudstove workshops. The mudstove design is the same as that promoted by NGO A in Otash.

NGO C worked in close cooperation with the traditional leaders (*omdas* and *sheikhs*) and community committees to select and organize the IDP women in groups to attend the improved mudstove training workshops. Each group included 50 women, who built their own stoves under the supervision of the trainers. NGO C provided the training and raw materials, mainly clay and animal dung, at no charge. The trainees received instruction on environmental degradation, the disadvantages of the three-stone fire, the advantages of the mudstove, and a demonstration of the effective use of mudstoves and fuel conservation skills. Stove maintenance issues mainly focused on avoiding pouring water on the stove while it is hot, and keeping the stove inside the kitchen during periods of rain. NGO C indicators for the FES program include number of beneficiaries receiving FES and number of FES trainers trained. NGO C staff in Kabkabiya reported that the program had trained 900 IDP women to become mudstove trainers, and 9,000 households in Kabkabiya and Saraf Omra owned one of the mudstoves by mid-2008.

Photo 5.8: Basic construction of a six-brick stove before it is plastered with clay

In 2007, NGO C obtained additional funds for FES dissemination in North Darfur IDP camps. Working with two partner NGOs—a local NGO and an international NGO specializing in FES—NGO C introduced a new stove design into its FES program, referred to here as the six-brick stove (see Photo 5.8). This stove had been piloted elsewhere in East Africa by NGO C's international partner.[7] Project implementation first took place in Al Salam IDP camp in El Fasher and then moved to Kabkabiya. The project intervention in Kabkabiya was for a very short period of only three months, April to July 2007. By the time the evaluation team arrived in Kabkabiya, the project was no longer active and the staff had been transferred to other projects.

[7] The FES evaluation of Northern Uganda mentioned in the introduction evaluated the six-brick stove disseminated in IDP camps there. The Uganda report is available at: www.usaid.gov/our_work/economic_growth_and_trade/energy/publications/EGAT0020.PDF

The design of the six-brick stove introduced by NGO C in Kabkabiya was inspired by the "Rocket Stove," in which the combustion chamber is L-shaped and made of insulative material. The use of a pot skirt is strongly recommended.[8] The main body of the six-brick stove is made of five and one-half bricks of special shape tied with a metal wire. The stove is completed by plastering a mixture of clay and animal dung on the bricks. There are two visible differences between the Ugandan stove and the Darfur stove (see Photos 5.9 and 5.10). The Darfur stove has an additional flange on top of the main stove body and the firewood feeding door has been extended.

Photo 5.9 Six-brick stove in Uganda

Photo 5.10: Six-brick stove in Kabkabiya

NGO C converted five of the original mudstove centers to be used for assembly of the six-brick stove. The target was to train 5,000 women to assemble and receive stoves. NGO C provided some tools for stove assembly, mainly saws for cutting bricks and wire cutters and wire for tying the bricks together.

The production of the bricks was contracted to a brickmaker in Kabkabiya, who was provided with the molds and trained on preparing the clay body mixture. The cost was fixed at SDG 150/US$75 per 1,000 bricks. The evaluation team did not visit the brick production site since production had stopped. However, there was a large stock of bricks at the stove centers, enough to produce 3,000 stoves. On closer investigation of the bricks, it became clear that the clay body mixture for the stove bricks did not differ much from that used for normal construction bricks, leaving the bricks unlikely to yield the insulating properties envisioned by the original stove designer. The estimated production cost for one six-brick stove is about SDG 12/US$6.

NGO C employed 20 trainers to teach women how to cut wire and tie the bricks together, and then cover the bricks with clay. In addition, three monitors demonstrated correct use and maintenance of the stoves and provided follow-up after the stoves were taken home. The 20 trainers were selected after taking a written examination, a process which excluded many IDP women who are illiterate. The IDP women who were excluded, however, might have been more

[8] For more information on Rocket stoves, see http://www.aprovecho.org/web-content/publications/publications.html.

adept at working clay. The trainers interviewed by the evaluation team revealed that they were not using wood stoves at home; they cooked with either charcoal or liquid petroleum gas (LPG). Communication between the trainers and the trainees may not have been as effective as it might have been had IDP residents been used as trainers.

For the six-brick stove, NGO C used the same dissemination approach as that used for the mudstove. All production materials and implements were provided by the NGO, and households were trained on stove assembly. The women were selected for training through the traditional leaders and community committees. NGO C was able to produce and distribute 3,000 six-brick stoves in Kabkabiya. Before closing the project, there was an effort to encourage some of the women to produce and market the stove themselves. NGO C provided the bricks to the women who were then supposed to collect the clay and animal dung and make the stoves. The selling price was fixed at SDG 12/US$6. When no stoves were sold, the price was reduced to SDG 10/US$5 and then further down to SDG 5/US$2.50, but even then the women reported that no stoves were sold.

6. END-USER ATTITUDES

6.1 HOUSEHOLD SURVEY

The evaluation team conducted a household survey of 150 IDP families in Otash and Kabkabiya to obtain information on attitudes, practices, and behaviors that could have an impact on household energy use. The most important questions of the survey were concerned with satisfaction with improved stoves. The results were uniformly positive, with almost all users of improved stoves indicating satisfaction. In more open-ended questions about which attributes of the stoves they liked or disliked, almost all respondents indicated that they thought the improved stoves reduced fuel consumption and were safer to use than three-stone fires. In terms of dislikes, the most common negative comment was that many users of improved stoves thought that the stoves were expensive. It is hard to interpret the latter response since most of the NGOs distributed their stoves for free. Perhaps the response reflects some women's frustration at the long wait to obtain a stove or the prices for some stoves on the market (although, as noted in the previous section, few, if any, of the stove entrepreneurs interviewed were still selling stoves).

Table 6.1: Likes About Improved Stoves

	Percent of respondents with affirmative response				
	AVI3	**NGO C Mudstove**	**NGO A Mudstove**	**Six-Brick**	**Tara**
	n=39	n=33	n=13	n=8	n=3
Modern	5%	6%	–	25%	–
Easy to use	38%	27%	62%	–	–
Saves time	74%	73%	54%	50%	67%
Saves fuel	95%	94%	100%	63%	100%
Safer than three-stone	74%	67%	92%	38%	67%
Cleaner than three-stone	18%	52%	8%	50%	–
Remains warm overnight	8%	9%	–	38%	–
Less smoke than three-stone	13%	24%	–	–	–
Less supervision needed	5%	6%	8%	–	–
Other	5%	–	–	13%	–

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.

Table 6.2: Dislikes About Improved Stoves

	Percent of respondents with affirmative response				
	AVI3	NGO C Mudstove	NGO A Mudstove	Six-Brick	Tara
	n=25	n=17	n=4	n=7	n=1
Expensive	68%	82%	50%	57%	–
Hard to use	4%	6%	–	57%	–
Lots of smoke	–	6%	25%	29%	–
Takes up too much space	–	–	–	14%	–
Hard to prepare meal	–	–	–	14%	100%
Too heavy	20%	–	25%	14%	–
Gets damaged by rain	–	29%	–	–	–
Cannot think of dislikes	28%	6%	50%	–	–
Other	48%	35%	25%	29%	–

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.

Women were asked about their experiences with the stove production and dissemination components of each FES project, especially the training components. The results were positive overall, though with some evidence of room for improvement. With the AVI3, for example, only about half of the women were satisfied with the training provided on how to make and maintain or repair the stove. It should be noted that not all women who were trained to make AVI3 stoves were invited back to produce stoves in the workshop. This may have engendered feelings that they had lost a valuable opportunity due to inadequate training rather than their own inability to consistently produce a quality stove in the workshop. Women expressed satisfaction with training on how to use the stove properly and employ energy-efficient practices. However, the team's observations of actual cooking practices indicate that the nearly universal claim that most beneficiaries employed fuel-efficient practices (such as splitting wood) may be exaggerated (based on observations during the cooking tests, the figure may be closer to 50%). More information on the responses to the household survey may be found in Appendix B.

6.2 FOCUS GROUPS

The evaluation team also conducted focus groups and informal discussions with stove users throughout the field research period. Focus groups consisted of FES users, FES producers, women who cooked for commercial purposes and women who did not own FES.

In one focus group of nine AVI3 users, the women agreed that they found the AVI3 superior in most ways to the *ladaya*, as well as the Tara. Some of the women in the focus group had been involved in building the AVI3 but as most producers were rotated after two weeks of production, ordinary women producers presumably had no strong vested interest in one stove vs. the other. One said she bought the Tara stove, but had stopped using it because it was dangerous for her children (because the stove's exterior gets so hot). She also noted that the AVI3 was difficult to use with the larger pot sizes (numbers 4 and 5).

A focus group of six-brick stove users was asked to compare the six-brick stove to the *ladaya* and NGO C mudstove. Almost all of the women expressed their dislike for the six-brick stove for the following reasons:

- It is difficult to ignite
- It takes more or the same amount of fuelwood as the *ladaya*
- It is too high for the cook when she sits on her traditional stool to cook *asida* and not stable for making *asida* unless she is assisted by someone holding the pot
- *Kisra* (pancake-like flatbread) cannot be cooked on the stove because when the cook sits, the stove is too high and when she stands it is too low
- Assembling the stove requires a lot of tools the women are not used to using, and making the six-brick is more difficult than making a mudstove
- The stove cannot accommodate multiple pot sizes

It was noted, however, that the six-brick stove is good for making charcoal from left-over embers, which was perceived as a benefit. The stove also keeps embers warm for a long time; therefore relighting the stove is very easy and rapid if one needs to heat water for tea or prepare another meal.

Women in the focus group thought that NGO C's mudstove was quite nice. It could be stored in the home in a bedroom and was moveable. It saved time and fuelwood, and produced little smoke. Focus group members noted that the number of women who wanted to receive training in production of NGO C's mudstove increased over time.

One of the evaluation team members recorded casual comments on various positive and negative attributes of the different stove types heard during the controlled cooking tests and during the time spent in the camps. A summary of the comments follows.

Tara stove:

- Easy to light
- Saves firewood but is smoky
- Burns to children and cooks were reported due to the exterior metal getting very hot
- Unstable when stirring *asida* (porridge). The task needs two people: one to hold the stove and the other to stir, or the cook may use her foot and a wood stick to make the stove stable
- Food cooked on this stove does not taste good
- Expensive
- Some prefer to use as a charcoal stove

AVI3 stove:

- The fire can be easily controlled except when it is windy
- Saves fuel
- Conserves heat
- Can be used as a charcoal stove
- In windy weather the flame comes out of the stove and causes fire
- If a lot of firewood is used, the stove will smoke
- Too heavy to move from place to place
- Prone to cracking, and especially sensitive to being moved if not completely dry
- The durability of the stove is limited even if precautions are taken

Mudstoves:

- Save firewood
- Moveable
- Little smoke
- Clean and easy to use
- White ants eat the organic material in the clay and this deteriorates the stoves
- Cannot bake kisra (flatbread)

Six-brick stove:

- Conserves burning embers; good for making charcoal
- Easy to re-light
- Height of stove unsuitable for cooking (especially for young cooks)
- Too heavy to move
- Consumes a lot of firewood
- Difficult to control in windy weather
- Sometimes takes a lot of time to complete cooking
- The stove is ugly and hurts the hands of the women during the building process

The usefulness of these comments, which are more specific and detailed than the information gleaned from the household surveys points to the importance of using a combination of data-gathering techniques in evaluating FES programs. Household surveys are more formal than focus groups and impromptu discussions, and rely on the respondent's capacity to recall certain answers. The information gathered through participant observation, informal interviews, and the cooking tests reflects actual behavior rather than recall and therefore is critical to determining how to improve the design and use of a specific stove to optimize its usefulness and efficiency.

7. FUEL EFFICIENCY BASICS

7.1 OVERVIEW

A stove's fuel consumption can be influenced by a number of factors, including altitude, climate, and cooking method (e.g., frying vs. boiling). All of these factors must be taken into consideration when designing or selecting the appropriate FES for a given population. Generally speaking, the key factors that determine fuel consumption include:

(a) *Fuel type and characteristics:*
The combustion qualities of a particular fuel are affected both by its inherent physical properties and the way in which it is prepared. Some fuels simply contain more energy than others (LPG, for example, contains much more energy per unit of mass than wood). In the case of wood, variables that may affect its quality (hence consumption) include moisture content, density, and oil content.

(b) *Combustion efficiency:*
The amount of energy obtained from the fuel by burning it is known as combustion efficiency and will vary depending upon the design features of a given stove. Stoves that achieve high combustion efficiencies should require less fuel than those with lower efficiencies. Hot fires burn more cleanly and efficiently; so maximizing combustion efficiency requires finding the right mixture of fuel, air, and spark that will more completely burn the gases emitted from the hot wood. Accordingly, factors that affect heat containment and airflow (e.g., insulation) can be adjusted in stove designs to boost combustion efficiency.

(c) *Heat transfer efficiency:*
The transfer of heat/gases created by combustion to the pot is another important feature of stove design. Improved heat transfer (i.e., keeping hot gases in direct contact with the cooking surface and preventing leakage) should reduce fuel consumption.

(d) *Behavior of the cook:*
The cook's skill in preparing the food and fuel, tending the fire, and using the stove can have a major impact on fuel consumption.

In order to obtain objective, quantitative data on the performance of the stoves studied in Darfur, the team undertook a number of different tests to gauge the fuel consumption of the various stove designs. The tests also permitted the team to observe the behavior of the cooks and to follow up on their observations during focus groups and one-on-one conversations.

While there is no foolproof method for measuring cookstove efficiency, over the years researchers and stove designers have developed several protocols that provide a rational basis with which to test and compare stoves. The evaluation team utilized two different protocols in order to gain a broad perspective and test the applicability and utility of the protocols in humanitarian emergency settings, which pose unique challenges due to access and security constraints. The results of these tests are summarized in the next section.

7.2 WATER BOILING TESTS (WBT)

7.2.1 INTRODUCTION

WBTs were one of the tools used as part of the evaluation methodology to help gauge the efficiency of the various stove models being used in the IDP camps. The chosen WBT protocol was designed to provide reliable information to stove designers about the performance of different wood-burning stove designs by standardizing as many variables (such as type and amount of fuel used and climatic conditions) as possible. The evaluation team decided to undertake WBTs to gain a better understanding of the stove designs being promoted in the camps, and to ascertain whether the WBT would be a useful tool for NGOs in the field.

The WBT consists of three phases that determine a stove's ability to:

- bring water to a boil from a cold start;
- bring water to a boil when the stove is hot; and
- maintain the water at simmering temperatures.

The test results yield a stove's thermal efficiency (the combination of combustion efficiency and heat transfer efficiency). By measuring the amount of time and fuel needed to perform the above three tasks, a stove designer can gauge the efficiency of a particular design and make changes. The standardized conditions and criteria also make it possible to compare efficiencies of different stove designs.

The WBT procedure is usually carried out by a laboratory technician or researcher under controlled conditions to reduce variability, and may not reflect stove performance under actual conditions. It is worth noting that stove efficiencies achieved in controlled laboratory settings are usually higher than those attained in a real-life situation. The WBT is a simplified version of the University of California Berkeley/Shell Foundation revision of the 1985 VITA International Standard Water Boiling Test[9]. The wood used for boiling and simmering, and the time to boil are found by simple subtraction. All calculations can be done by hand in the field.

7.2.2 METHODOLOGY

In order to test stove performance in conditions as close as possible to those of the users, the team modified the standard WBT in several ways. Given the lack of time for the testing due to the security situation and the difficulty of transporting heavy, fragile mudstoves to a laboratory setting, the team opted to conduct the WBTs in the evening at the team lodging. The stoves used for testing were borrowed either from camp residents or the production sites. The Tara stoves were new, taken from the workshop. The AVI3 and NCO C mudstoves were also relatively new stoves in good condition. The mudstoves found in Otash (NGO A) were older and somewhat deteriorated, so the team used a combination of the older stoves and newer ones made specifically for the WBTs. Although newly built for the testing, the mudstoves were allowed to dry for 3-4 days prior to being tested.

Another modification of the standard WBT procedure was to use the smaller pot size commonly used by the end-users, instead of the larger size recommended by the Berkeley/Shell protocol. The most common cooking pot used in Darfur IDP camps is a round pot made of cast aluminum. The smaller size of the cooking pot used in the test necessitated a reduction in the

[9] For more information on the WBT and controlled cooking test (CCT) protocols, see http://ehs.sph.berkeley.edu/hem/page.asp?id=42.

volume of water boiled in the WBT from the 5 liters recommended in the protocol to 3 liters. Time limitations also required the team to conduct the WBTs at different times during the evening, since the days were spent in the camps conducting surveys, focus groups, and controlled cooking tests. Testing conditions were thus quite variable as air temperatures dropped in the evening. Some of this variation was controlled by testing three stoves from each stove model. Each stove model was subjected to testing during different time intervals. Finally, the WBTs were carried out by the evaluation team (both women and men, and all experienced in building fires with wood-burning stoves) without the involvement of the end-users.

During the tests the following information was recorded: (i) time to boil water; (ii) wood used during the testing phases and charcoal produced; and (iii) water lost as steam, measured as the difference between the weight of the water at the beginning of the test and then at the end of the test. These observations were used to calculate the thermal efficiency (the percentage of the energy contained in the firewood delivered to the contents of the cooking pot) of the different stoves.

The efficiency calculations here are a considerable simplification of the standard protocol. Fuelwood moisture was not measured, and no adjustment was made for differences in the air and water temperatures. Charcoal residues were not included in the calculations. The thermal efficiency calculations that resulted therefore are not comparable to those taking into account all of these factors. The data collected should be useful for detecting potential problems in stove designs, but may not reflect how stoves perform under actual cooking conditions.

7.2.3 WBT RESULTS

In Otash, three stoves of each type (mudstove, AVI3 and Tara stoves) were each tested three times, for a total of 27 tests. In Kabkabiya, three different mudstoves were tested 2-3 times each, for a total of seven tests, and three six-brick stoves were tested 2-3 times each, for a total of eight tests. In addition, one Tara stove was tested one time. The three-stone fire was tested five times in Otash Camp and three times in Kabkabiya (using two *ladaya* in Otash and one in Kabkabiya). The small number of tests and sizable variability across tests for the same stoves and stove groups mean that the findings should be considered indicative only.

The results of the WBTs are summarized in Table 7.1. Quite clearly, the six-brick stove performed poorly, worse on every indicator than the other improved stoves and worse than the three-stone fire. The other improved stoves performed better than the three-stone fire in the cold start and simmering portions of the test, but less well in the hot start portion. On average, the improved stoves (not including the six-brick) achieved thermal efficiencies around 50% better than the open fire. The overall differences between the mudstoves, AVI3, and Tara stove were very small. Differences between the open fire and improved stoves for time to boil were not significant except in the case of the six-brick stove, which took twice as long to boil water from a cold start than virtually all of the other stoves, including the three-stone fire.

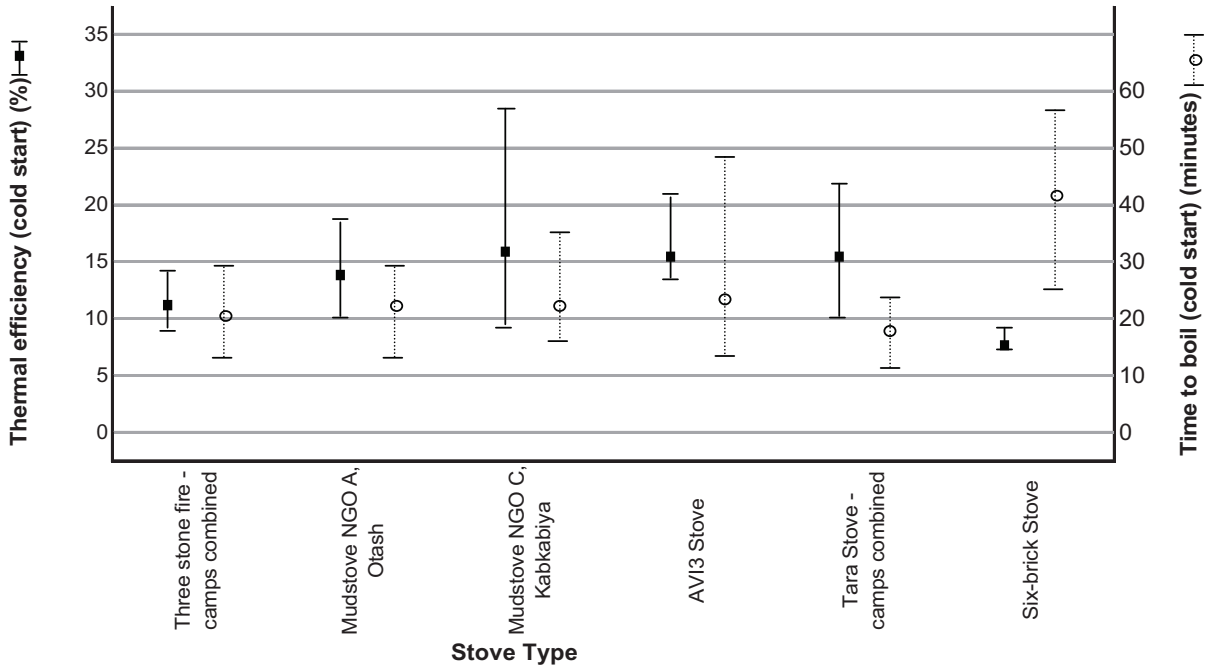
Table 7.1: Results Of Water Boiling Tests

		THERMAL EFFICIENCY				TIME TO BOIL (minutes)	
		cold start	hot start	simmer	Average of cold, hot, simmer	cold start	hot start
NGO A Mudstove	3 stoves, 8 tests total	13.8%	11.6%	36.1%	20.8%	21.4	17.4
NGO B AVI3	3 stoves, 9 tests total	15.4%	13.8%	32.3%	20.5%	23.8	14.7
NGO B Tara	4 stoves, 10 tests total	15.8%	14.0%	32.6%	20.8%	18.0	15.1
NGO C Mudstove	3 stoves, 7 tests total	15.9%	15.7%	28.4%	20.0%	22.1	18.1
NGO C Six-brick	3 stoves, 8 tests total	7.6%	9.0%	10.1%	8.9%	42.1	21.0
3-Stone – both camps	3 fires, 8 tests total	11.9%	12.6%	16.3%	13.6%	20.6	19.9

Team members believe that the poor performance of the six-brick stove reflects changes made in the Darfur model. Although the six-brick stove design was inspired by the Rocket stove, which is widely considered to be energy efficient, the Kabkabiya model features an increased distance between the fire and the pot. In addition, the stove skirt was replaced by a flange with high pot rests. The portion of the pot surface touched by the flame appeared to be very small, reducing heat transfer efficiency. In addition, the bricks did not appear to contain adequate filler or be fired in a way to maximize insulation; instead, the bricks and the earthen mass surrounding them likely absorbed a significant amount of the stove's heat.

The WBT results show that three of the four types of improved stoves (both types of mudstoves, AVI3, and Tara) generated higher thermal efficiency ratings than the three-stone fire, particularly when it came to simmering. Improvements in the thermal efficiency of the improved stoves compared to the three-stone fire for the cold start (which typically reflects the task with the highest fuel consumption) ranged from around 16% to 34%. The performance of the various stoves in the WBTs for the cold start is shown in Figure 7.1. The square and circle represent the average thermal efficiency and time to boil, respectively, while the vertical line represents the range of values recorded for each type of stove. There was considerable variation between WBTs for each stove tested, but the average efficiency for three of the five improved stoves was virtually indistinguishable.

Figure 7.1: Thermal Efficiency Of Stoves During Water Boiling Tests



The small differences in the average thermal efficiency and time to boil amongst the improved stoves (except for the six-brick) indicate that potential differences in fuel consumption during actual cooking conditions may be attributable more to end-user behavior than stove design. The WBT results suggest that choices about prioritization of one model over the other should be made carefully, and only after further monitoring and evaluation (which includes non-efficiency criteria, such as cost considerations, durability issues, and supply-chain issues, in addition to efficiency testing) is conducted.

7.3 CONTROLLED COOKING TESTS (CCT)

7.3.1 INTRODUCTION

In addition to the water boiling tests, the evaluation team also conducted controlled cooking tests. These tests were designed to assess the performance of the improved stove relative to the common traditional stoves that the improved model is meant to replace. Stoves are compared as users perform a standard cooking task similar to the actual cooking conducted in the camps every day. The tests are standardized as much as possible in terms of ingredients and instructions, in a way that minimizes the influence of other factors and allows for the test conditions to be reproduced. The test measurements and processes may be used to:

- Compare the amount of fuel used by different stoves to cook a common food;
- Compare the time needed to cook that food; and
- Observe actual cooking practices, especially regarding application of efficient use and fuel conservation skills.

7.3.2 METHODOLOGY

The most commonly eaten food in Darfur, particularly in IDP camps, is *asida* (a thick porridge made from millet or sorghum) and *mulaah* (a sauce typically made from local greens and vegetables), so this is what the team asked the cooks to prepare. Due to the number of stoves to be sampled, the significant distances between households, and the security risks around the

camps, the evaluation team found it impractical to conduct the CCTs in the individual household kitchens. Instead, the women's centers within the IDP camps were selected as the best place to carry out the trials. Three stoves from each stove model were selected (with no particular basis for the choice other than convenience) and either brought to the center by the women cooks or borrowed from the production facility.

Twelve IDP women in Otash volunteered to conduct the cooking tests using their own stoves or the model they cooked on at home. They each conducted three cooking tests, three different cooks for each stove type (AVI3, Tara, NGO A mudstove, and three-stone open fire) outside, under shade (almost open-air conditions). Two of the Tara stoves came from the homes of the women who were cooking, and one was brought from the workshop. For the AVI3, only one woman brought her own stove, so the other two were borrowed from the CHF production center. All of the mudstoves belonged to the cooks. A total of 36 tests were conducted.

Ten IDP women in Kabkabiya volunteered to conduct the cooking tests. Except for the Tara user, each woman used her own stove or the model she cooked on at home, and conducted the cooking test on that stove three times over three days (the same cook is used to reduce variability in cooking behavior). There were three stoves each of the six-brick, NGO C mudstove, three-stone open fire, and one Tara stove, making a total of 30 tests. These tests also were conducted outside, under shade (almost open-air conditions).

The women were told to cook as they usually did at home. There were no inducements, and all the women were volunteers. The cooked food was served as breakfast for the team, cooks and the men and women who were working in the surrounding areas or passing by. In addition, tea and coffee were served. On the final day, the CCT team members organized a small ceremony with the women, and the team publicly thanked the women for their participation and offered the cooks the cooking pots and the remaining firewood. During the trials and the ceremony the atmosphere was relaxed and convivial.

The evaluation team supplied all of the ingredients, materials (cooking utensils for stirring, implements for fanning the fire), fuel, and pots. The cooks were given the same amount of ingredients to cook with, as shown in Table 7.2.

Table 7.2: Ingredients Distributed To Cooks For Each CCT

Food & spices	Qty (gram)	Remarks
Millet flour	1,500	
Onion	450	
Dried meat	110	
Dried tomato	70	Powder
Dried okra	100	Powder
Garlic	60	
Cinnamon/other spices	20	
Fennel	20	
Cayenne pepper (*shatta*)	40	Powder
Salt	100	
Coriander	20	
Vegetable oil	250	
Firewood	~ 6 kg	Each bundle of fuelwood was weighed and recorded. Slight differences in the quantity of each bundle were taken into account.

During all of the CCTs, the women started by cooking *mulaah* first, using the small #2 size pot, and then prepared *asida,* using a #3 size pot. In general, the cooking style for all women was very similar:

- They cooked *mulaah* before *asida*
- They used the same stove for cooking *mulaah* and *asida*
- They prepared major ingredients before lighting the fire
- They prepared spices during cooking
- They did not use lids for *mulaah* pots
- They boiled water as a first step for cooking *asida* (typically with a lid)

7.3.3 CCT RESULTS

The CCTs measured two factors, since both are important to the cooks: fuelwood consumption and time to cook. The averages for these measures are reported in Table 7.3. Cooking time started when the first pot was put on the fire. The cooking time for most stoves varied from 60 to 90 minutes, while the fuelwood required to cook the meal was on the order of 2 kilograms.

Table 7.3: Results of CCTs

Stove technology	Number of CCTs	Average fuelwood used for CCT (kg)	Average time taken to cook (minutes)	Fuelwood consumption Rate (g/min)
NGO A Mudstove	9 tests, 3 stoves	1.95	71.22	27.34
NGO B AVI3	9 tests, 3 stoves	2.20	67.00	33.12
NGO B Tara	12 tests, 4 stoves	1.67	85.33	19.29
NGO C Mudstove	9 tests, 3 stoves	1.02	64.89	15.91
NGO C Six-brick	9 tests, 3 stoves	2.02	63.56	31.46
3-Stone – both camps	18 tests, 6 stoves	1.92	71.22	27.76

Although the relatively small sample means the test results should not be considered definitive, the CCTs reveal some interesting information. Distinctions in stove performance are more marked between the improved stoves than in the WBTs, and performance of some improved stoves relative to the three-stone fire was poor. However, on the positive side, NGO C's mudstove performed considerably better—nearly 50%—than the three-stone fire in terms of fuel consumption, and also cooked faster. NGO A's mudstove, though the same design as NGO C's, performed about the same as the three stone. However, the NGO A stoves used in the CCTs were older than the others and somewhat deteriorated, which likely had a negative impact on their performance (see Photo 7.1 below). The six-brick stove used more fuel than the three-stone fire in the CCT, but cooked faster. While the Tara stove used less fuel on average than the three-stone fire, it was considerably slower and averaged the longest of the stoves for time taken to cook the meal.

Photo 7.1: Woman cooking during CCT with damaged NGO A mudstove—an entire section is missing above the fuel entry door.

The cooking trials reinforce the evidence of the WBTs and focus groups that the six-brick stove should not be promoted further without design modifications. The stove must be fed continuously with fuel in order to keep heating the pot, otherwise the temperature of the pot's contents will immediately start to drop. The gap between the pot and the stove is too large; as a result, wind sometimes blows the fire in the reverse direction. One woman used a brick to close the six-brick stove's door to avoid excessive drafts and thereby reduce the stove power to the required level. The AVI3 stove also exhibited problems with draft, due to its two air inlets. At times the cooks were unable to control the amount of air entering the stove. As a result, too much air was entering the fire chamber, increasing the burning rate and causing the flame to escape from the stove. In addition, the spaces between the iron bars in the AVI3 grate are too big to capture small pieces of wood. This means that small pieces of wood and charcoal fall into the air chamber, which reduces the stove's efficiency.

The cooking trials exhibited much variation in fuelwood consumed and time elapsed both within and between stoves (see Figure 7.2). The amount of fuelwood used ranged from .78 kg to more than 3 kg to prepare the same meal. The time elapsed during cooking also varied from a low of 54 minutes to a high of 99 minutes. The biggest fuelwood user in Otash, using an AVI3 stove, cooked her meal in 61 minutes using 3 kg of wood. The lowest fuelwood user in Otash, using the three-stone fire, burned 1.09 kg of wood and took 64 minutes to cook the meal. In Kabkabiya, one mudstove required only .78 kg of wood to cook a meal in slightly over 60 minutes. Another woman, using a three-stone fire, used 2.74 kg of wood to cook the meal, more than three times as much, while also taking just over 60 minutes. The Tara stove user in Kabkabiya, where only one stove was tested, did not own the stove, but outperformed the experienced Tara users in Otash, using an average of 1.15kg of wood and 75 minutes to cook a meal, compared to 1.84 kg and 89 minutes for the Otash users. Within each stove category, the high values were double or triple the low values.

The range in values recorded within each stove category shows the large influence of the cook in determining the amount of fuel consumed by any given stove. For example, some women engaged in energy-saving practices, immediately splitting the wood into small pieces, or using the outgoing flame from the three-stone, while cooking *mulaah*, to heat water for the *asida*. Some of the women in Kabkabiya seemed to be trying to cook quickly, and the team later learned that they wanted to go to their usual income-generating activities in the town. The

women cooking in Otash, in contrast, seemed very relaxed, and certainly were not rushed. The team interpreted this to the "lock-down" environment in Otash Camp during that period, when violence on the outskirts of the camp made leaving the camp less advisable. There was a substantial difference between the three-stone fire trials in Kabkabiya and Otash in terms of time to cook the meal, though the average amount of fuelwood used was practically identical (it may be that the quality of meals cooked in Kabkabiya was worse). The difference in attitude of the cooks in the two camps could have skewed the results, particularly the data showing the rate of fuelwood consumption (g/min).

Figure 7.2: Energy And Time Used During Controlled Cooking Tests

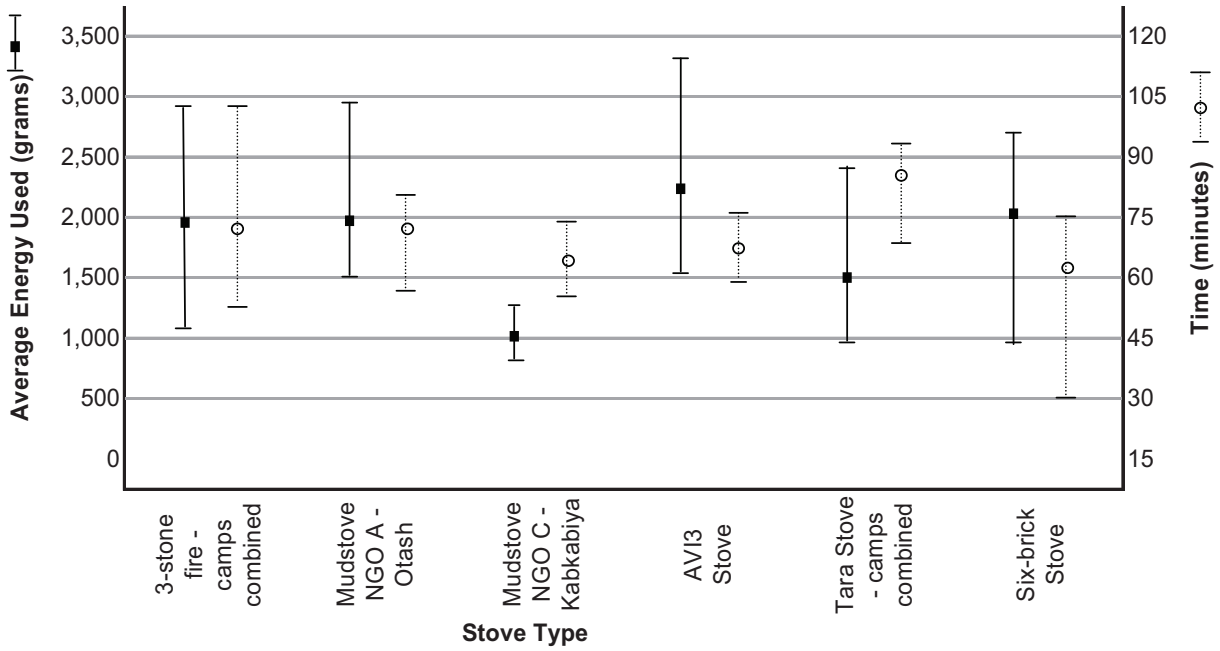


Figure 7.2 depicts the performance of the various stoves in the CCTs. The vertical lines represent the range of values recorded for each particular type of stove. The squares represent the average energy used while the circles represent the average time to cook. NGO C's mudstove showed the least amount of variability.

It is interesting to aggregate the fuelwood used and the time taken to cook the meal by expressing them both in value terms and adding them together. For comparative purposes, assume fuelwood is valued at .25 SGD (US$0.125) per kilogram (the price in Otash), and an hourly wage is SDG .5 (US$0.25). (This is a very conservative value for time; the team found that the wage for a person working an entire day might be on the order of SDG 8/US$4, which implies an hourly rate of 1 SDG/US$0.50). Given these assumptions, the average cost to cook a meal in Otash would be lowest for the NGO A mudstove at SDG 1.08/US$0.54, highest for the Tara stove at SDG 1.20/US$0.60, and SDG 1.13/US$0.56 for the three-stone fire. With the same assumptions for Kabkabiya, the average cost to cook a meal is lowest for the NGO C mudstove, at SDG .80/US$.40, highest for the six-brick stove, at SDG 1.03 /US$0.52, and SDG 1.01 /US$0.51 for the three-stone fire. These calculations are for comparative purposes only; other values could be assigned for time and fuelwood that would change the calculations.

Regardless of how the time and fuelwood are aggregated, the CCTs conducted by the evaluation team suggest that average fuel savings for some of the improved stoves may be

significantly lower than the rates claimed or assumed by many FES promoters and programs. In fact, if all of the results for the improved stoves are aggregated, the improved stoves averaged 1.77 kg fuelwood per meal, compared with 1.92 for the three-stone fire, a savings of about 8%. To get an idea of the value of just the fuel-savings component of these programs, one can multiply the fuel saved per meal (about .15 kg) times the cost of fuel, which is SDG .25 /kg, times two meals per day (which is conservative), times 365 days in the year. This comes out to about SDG 27 per year, or about $13.50 per household per year in direct savings of fuelwood. (If the six-brick stove is excluded, the average fuelwood use per meal for the improved stoves is 1.71 kg, which results in fuel savings of about $18.50 per household per year). As noted earlier, the cost of a mudstove is only about SDG 5/US$2.50, so the mudstove quickly pays for itself if this efficiency is maintained (which seems unlikely, based on the differences observed and recorded in the performance of the NGO A and C mudstoves). Other improved stoves are more expensive, and the indirect costs of running the FES programs (as well as the indirect benefits) need to be factored in to determine whether the programs pass a reasonable cost-benefit ratio for an emergency setting.

The fact that households in Darfur reported satisfaction with most of the FES programs despite the poor performance of some stoves in the team's tests needs more investigation. The discrepancy may reflect problems with the team's stove testing methodology, or may reflect a "false positive" (when a consumer reports being satisfied with an inferior product or service)[10]. In some cases, feedback might reflect a stove user's initial impressions, even if a stove's performance wanes over time. User happiness may also reflect the setting and user expectations rather than just product performance. Most beneficiaries in humanitarian contexts are grateful for the assistance they receive and are hesitant to criticize aid programs for fear of offending the aid providers or negatively influencing their chances of accessing additional assistance. This makes it very difficult to determine whether goods or services provided need to be modified or improved for optimal effect and outcome. Ways to improve the data-gathering process include: (1) using independent evaluation teams whose members are not associated with any of the implementing organizations to the extent possible; (2) crafting survey instruments and monitoring protocols carefully so as not to guide beneficiary responses; (3) including data gathered from techniques that enable evaluators to observe end-user behavior and gather comments from cooks while actually cooking; and (4) selecting evaluators who understand the local languages and culture.

[10] See "Models of User Satisfaction: Understanding False Positives" by Rachel Applegate. *Reference Quarterly* 32(4):525-539, Summer 1993.

8. RECOMMENDATIONS

Successful FES programs can result in considerable socio-economic, safety, and health benefits for beneficiary households. In order to maximize the impact of FES programs, the evaluation team recommends the following:

1. Increase and improve monitoring and evaluation of the FES programs.

Some of the NGOs evaluated had made good efforts in this direction, but others seemed to have carried out virtually no monitoring and evaluation activities.

- The most basic monitoring involves keeping careful track of stove and fuel use. Regular controlled cooking tests should be carried out and the results recorded, in order to gauge fuel consumption patterns of various stoves, especially as design modifications continue to be made, as well as the behaviors/attitudes of cooks. One possibility would be to undertake cooking trials once a month when stoves are distributed, and have new stove users trained in cooking methods at the same time as stoves are tested and timed. A *ladaya* can be used at the same time for comparative purposes. CCTs for older stoves should also be conducted, to give FES designers/promoters more information on their performance. CCTs provide opportunities to bolster household behaviors that can reduce fuel consumption, including proper fuel preparation and tending of the fire, and to teach important concepts, such as the need to verify product claims by careful testing.

- Simple systematic follow-up should be conducted every six months throughout the life of the program. Women using the improved stoves should be asked to record the condition, use, and their satisfaction with the stove. A simple form for non-literate persons can be generated using pictures so that IDP women can complete the form (by circling a picture of whether the stove is in good condition or is cracked, for example). It is very important to present respondents with options for indicating the "strength" of their satisfaction. FES program staff can then add simple statistics of stove users to the monthly report on the controlled cooking trials.

- User satisfaction surveys are best carried out with specially designed single-focus instruments implemented by knowledgeable teams. Many NGOs have a temptation to ask generic survey questions such as, "Are you satisfied with your stove?" They then report high rates of user satisfaction. In an IDP camp context, where NGOs typically offer multiple, interconnected services, camp residents may be wary of being strongly critical of any given service program. To avoid this problem, surveys should be designed by knowledgeable stoves persons and ask leading questions that invite constructive criticism; e.g., "Some camp residents think that their new stoves use about the same amount of wood to cook as the *ladaya*. Do you agree? Do you use only your new stove to cook? Do you also still use the *ladaya*?"

- Techniques such as on-site observation, informal interviews, and focus group discussions, undertaken by trained staff who sit with cooks for extended periods to discuss their cooking habits and watch their stoves being used, are likely to generate interesting and useful information as a complement to a survey of user satisfaction. Discrepancies among different sets of data must be investigated to determine their causes.

- FES implementers should monitor production activities, keeping statistics on production output (how many stoves are produced) and costs (how much was spent on materials and labor). Monthly reporting systems from each production center should be instituted to track the number of stoves produced and disseminated, stove material costs and budgets, and observations on the production process.

2. Establish workshop-centered and quality-controlled production processes for stove programs.

Stove workshops where producers are paid to produce stoves subject to rigorous quality control and inspection can be implemented for any type of stove. End-user participation may be incorporated into the process, provided there is strict supervision and testing or monitoring of any work carried out by non-specialists. End-user participation may indeed increase knowledge about how to use and repair a stove effectively. Any production process should incorporate:

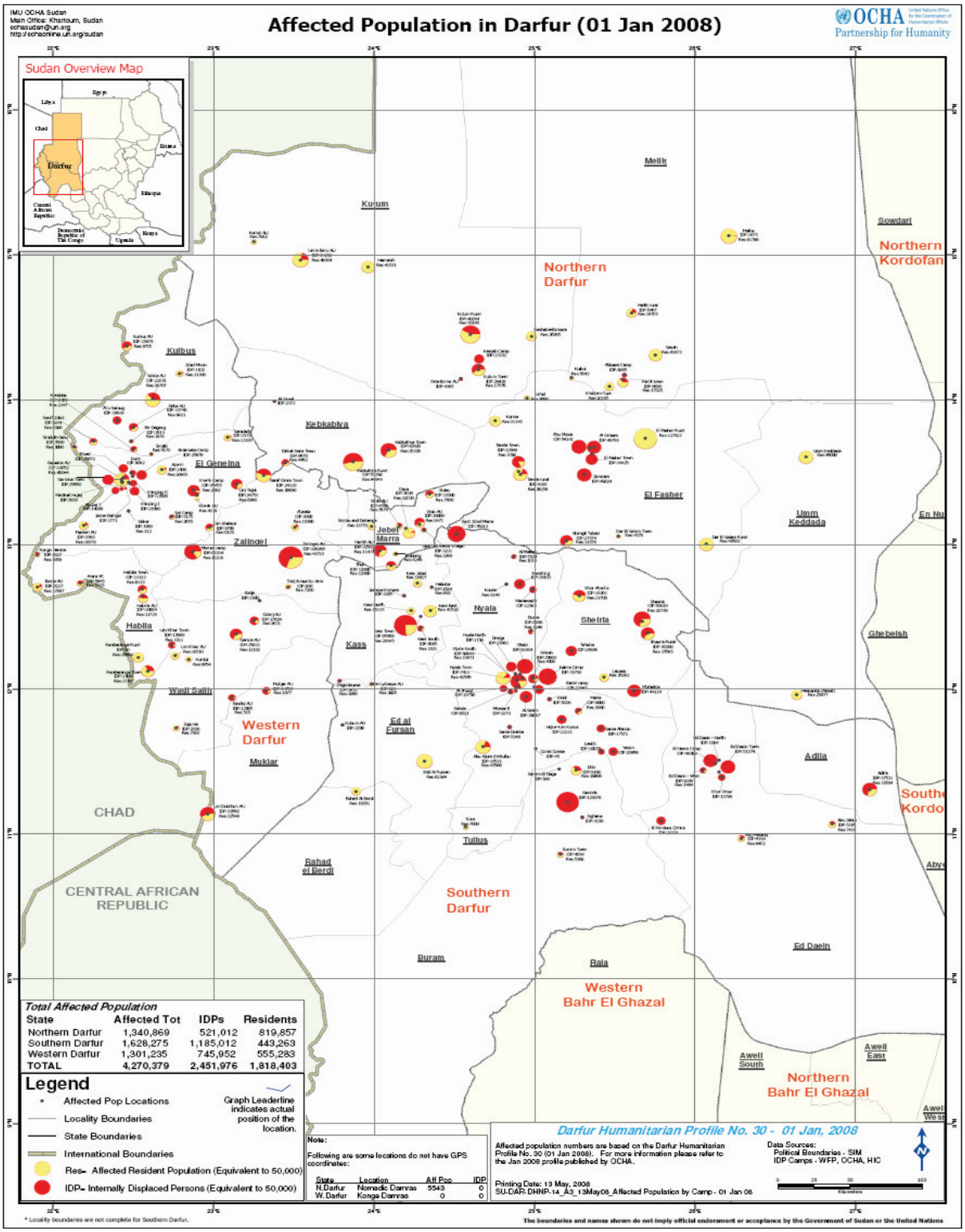
- The presence of a qualified stove specialist who is frequently onsite. The stove specialist should conduct spot inspections and performance tests in order to address technical issues regarding stove production. The specialist should also undertake stove performance comparison tests and seek to make stove modifications accordingly.
- Use of molds to ensure uniform dimensions for stoves made of mud or clay. Different mold sizes will be needed in order to produce stoves of different sizes.
- A plan for stove maintenance. This will necessitate paying attention to the entire stove supply chain, so that end users (or designated specialists) have access to materials needed for stove repairs and maintenance, even after NGO support ends.

3. Introduce more market-based accountability to the stove distribution process.

While FES programs may be implemented primarily to meet non-economic objectives (i.e., protection of women, mitigation of deforestation, etc), these results are unlikely to be achieved if use of the FES does not actually result in decreased fuel consumption. This objective may be more easily met by a thriving and accountable production sector that responds to incentives and feedback. The current strategy of most stove projects is for the implementing NGO to produce and distribute stoves for free. NGOs should consider charging a nominal fee, such as SDG 1/ US$.50, to encourage beneficiaries to take better care of their stoves and to promote sustainability of the stove program. The fees collected could be used to supply materials needed to mend stoves that have cracked, better promote fuel-saving cooking practices, or partially fund controlled cooking tests. This strategy can only be successful, however, if all FES implementers within a given area adopt the same approach; the evaluation team observed that some households had returned to using the *ladaya* rather than purchase a new stove or materials needed for stove repair, as they believed another NGO would eventually come along and give them a new stove for free.

In the meantime, NGO staff should follow through on reports that allocation of stoves through traditional leaders may be leading to exclusion of some eligible recipients. If verified, other distribution models (such as random allocation) should be pursued.

Annex A: Map of Darfur IDP Camps



Annex B: Select Results Of Household Survey

Table B1: Characteristics Of Households Surveyed In Otash And Kabkabiya Camps

	n=	Mean age of household head	Mean age of primary cook	Number of persons in household	Percent of household heads who write Arabic	Percent of primary cooks who write Arabic
Kabkabiya, female household head	14	38.6	37.2	4.4	0%	7%
Kabkabiya, male household head	37	40.0	30.3	6.8	59%	35%
Otash, female household head	22	38.2	34.2	5.8	18%	23%
Otash, male household head	77	45.6	31.5	6.7	49%	23%
Combined	150	42.5	32.2	6.4	43%	25%

Table B2: Number Of Meals Prepared And Expenditures On Fuelwood And Charcoal (SDG/US$ per week)

	Kabkabiya		Otash	
	Female household head	Male household head	Female household head	Male household head
Three meals	71%	95%	59%	82%
Two meals	29%	5%	36%	18%
Fuelwood				
Number of households buying	8	29	18	70
Average expenditure *(SDG/US$)*	SDG 8.88/$4.44	SDG 9.31/$4.66	SDG 11.56/$5.78	SDG 10/$5
Charcoal				
Number of households buying	1	4	12	51
Average expenditure *(SDG/US$)*	SDG 1.00/$.50	SDG 10.75/$5.38	SDG 6.50/$3.25	SDG 9.73/$4.87

Table B3: Energy-Saving Practices

	Percent of respondents saying they use this method			
	Kabkabiya		Otash	
	Female household head	Male household head	Female household head	Male household head
	n=14	n=37	n=22	n=77
Add soda ash (kombo)	93%	89%	95%	94%
Presoak beans before cooking	93%	92%	86%	92%
Add maggi cube or equivalent	100%	86%	60%	62%
Bank fire after use to preserve fuel	100%	100%	100%	99%
Cut fuelwood into small pieces	100%	100%	100%	100%
Dry wood before using	100%	100%	100%	100%
Cover pot with lid	100%	100%	100%	100%

Table B4: Likes About Traditional Three-Stone Fire (*ladaya*)

	Percent of respondents mentioning characteristics	
	Kabkabiya	Otash
Likes	**n=13**	**n=30**
Traditional	31%	10%
Cheap	8%	17%
Simple	62%	17%
Better	15%	17%
Ignites easily	23%	13%
Fits all pot sizes	31%	7%
Don't know any other	–	3%
Other	31%	47%

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.

Table B5: Dislikes About Traditional Three-Stone Fire (*ladaya*)

Dislikes	**n=31**	**n=47**
Dirty	49%	21%
Lots of smoke	42%	19%
Dangerous (causes burns)	32%	43%
Uses lots of wood	94%	72%
Could cause a house fire	29%	34%
Other	3%	11%

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.

Table B6: Satisfaction With Improved Stoves

	AVI3	NGO C Mudstove	NGO A Mudstove	Six-Brick	Tara
	Percent of respondents with positive response				
Are you satisfied with your improved stove?	96%	100%	87%	50%	100%

Table B7: Preparation For Using Improved Stoves

	AVI3	NGO C Mudstove	NGO A Mudstove	Six-Brick	Tara
	Percent of respondents with affirmative response				
	n=46	n=33	n=15	n=10	n=3
Did you receive your stove from an NGO?	87%	85%	67%	80%	67%
Did the NGO's training prepare you…					
to make the stove?	47%	100%	92%	100%	100%
to repair the stove?	44%	100%	83%	100%	100%
to use the stove?	85%	100%	83%	100%	100%
to use less fuel?	85%	100%	83%	100%	100%
to be safe with stove?	76%	100%	92%	71%	100%

Table B8: Likes About Improved Stoves

	Percent of respondents with affirmative response				
	AVI3	**NGO C Mudstove**	**NGO A Mudstove**	**Six-Brick**	**Tara**
	n=39	n=33	n=13	n=8	n=3
Modern	5%	6%	–	25%	–
Easy to use	38%	27%	62%	–	–
Saves time	74%	73%	54%	50%	67%
Saves fuel	95%	94%	100%	63%	100%
Safer than three-stone	74%	67%	92%	38%	67%
Cleaner than three-stone	18%	52%	8%	50%	–
Remains warm overnight	8%	9%	–	38%	–
Less smoke than three-stone	13%	24%	–	–	–
Less fire supervision needed	5%	6%	8%	–	–
Other	5%	–	–	13%	–

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.

Table B9: Dislikes About Improved Stoves

	Percent of respondents with affirmative response				
	AVI3	NGO C Mudstove	NGO A Mudstove	Six-Brick	Tara
	n=25	n=17	n=4	n=7	n=1
Expensive	68%	82%	50%	57%	–
Hard to use	4%	6%	–	57%	–
Lots of smoke	–	6%	25%	29%	–
Takes up too much space	–	–	–	14%	–
Hard to prepare meal	–	–	–	14%	100%
Too heavy	20%	–	25%	14%	–
Gets damaged by rain	–	29%	–	–	–
Cannot think of dislikes	28%	6%	50%	–	–
Other	48%	35%	25%	29%	–

Note: Percentages do not add up to 100% because respondents could mention more than one characteristic. Percentages are rounded to the nearest whole number.