Aprovecho Research Center
Advanced Studies in Appropriate Technology Laboratory
P.O. Box 156 Creswell, OR 97426 541-895-5677

Institutional Barrel Stoves in Northern Uganda
Theory vs. Reality

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"Freda"

Introduction

Twelve institutional barrel stoves were built in Gulu, Uganda and donated for use in schools, hospitals and feeding centers. The stoves were similar in design but used several different materials for the combustion chambers. These stoves will be monitored for durability of components and possible design changes. The stoves varied slightly in details and used a variety of different sized pots. Controlled Cooking Tests were done using one of the stoves to compare results from actual cooking practices with Water Boiling Tests done in the laboratory.

Costs of parts and labor for fabricating the stoves were recorded and compared with estimates for manufacturing the same stove in the US and in India.

Performance

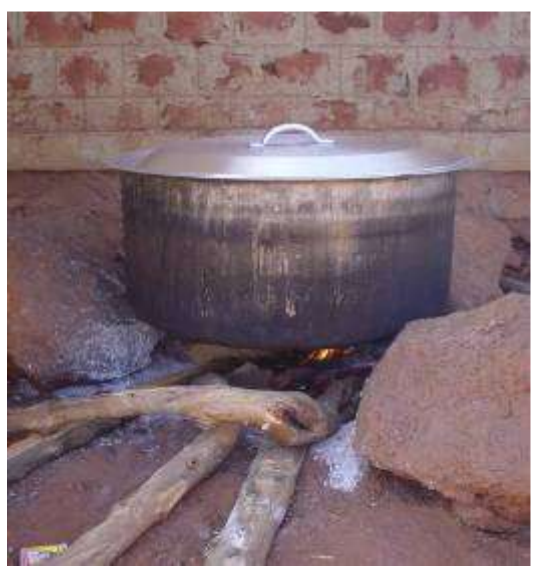
The institutional barrel stove was compared with the open fire using a modified version of the UCB (University of California Berkeley) Controlled Cooking Test (CCT). Identical amounts of yellow beans were prepared three times using each stove. The same pot was used in both stoves. All food was cooked by Freda Amono who was familiar with local cooking practices and helped choose the dish to be prepared. Freda chose all ingredients and fuel for use in the tests. Firewood was obtained from a nearby IDP

(Internally Displaced Persons) camp and was weighed before and after each test. Once Freda determined the quantity of each ingredient to be used, it was weighed and the same quantity of each ingredient was used in all tests. The time to cook and fuel used was recorded for each test.

These Controlled Cooking Tests differed from published UCB protocol by not adjusting the wood used for the quantity of char remaining at the completion of cooking. This change was made to reflect the local cooking practice of letting the fire burn out and cleaning out all ashes and char before a new fire is begun. Char is not saved or utilized for other purposes.

Buying firewood in Unyama IDP camp

Institutional barrel stove



Three stone fire

Controlled Cooking Test (yellow beans)

Results of CCT comparing two stoves

Stove type/model: Stove 1	**Three Stone Fire**
Stove type/model: Stove 2	**Institutional Barrel Stove**
Location	**Aid Africa Office, Gulu, Uganda**
Wood species	**Average Hardwood**

1. CCT results: Stove 1	**units**	**Test 1**	**Test 2**	**Test 3**	**Mean**	**St Dev**
Total weight of food cooked	g	14421	13512	16216	14716	1376.0
Weight of char remaining	g	1271	1018	1177	1155	127.9
Equivalent dry wood consumed	g	17740	13366	14990	15365	2211.0
Specific fuel consumption	g/kg	1230	989	924	1048	161.1
Total cooking time	min	256	205	201	221	30.7

2. CCT results: Stove 2	**units**	**Test 1**	**Test 2**	**Test 3**	**Mean**	**St Dev**
Total weight of food cooked	g	12773	12799	12664	12745	71.6
Weight of char remaining	g	399	319	341	353	41.3
Equivalent dry wood consumed	g	6269	5217	4943	5476	700.0
Specific fuel consumption	g/kg	491	408	390	430	53.7
Total cooking time	min	116	140	132	129	12.2

Comparison of Stove 1 and Stove 2		**Stove 2 /Stove1**	**T-test**	**Sig @ 95% ?**
Specific fuel consumption	**g/kg**	**41%**	6.31	YES
Total cooking time	**min**	**59%**	4.79	YES

Laboratory WBT (Water Boiling Tests)
Performed at Aprovecho Research Center Laboratory in Creswell, Oregon

Performance

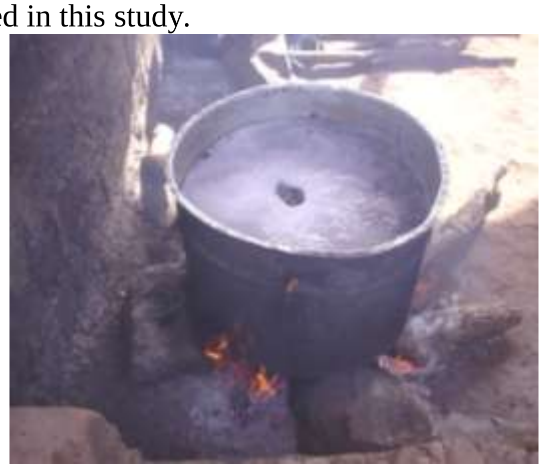
Institutional Barrel Stove vs. Open Fire
Fuel Use and Emissions per Liter of water
(boiled and simmered 45 Min)

		Institutional	Open Fire	Inst/OF
Fuel to Cook	grams/Liter	61.2	223.6	27%
Carbon Monoxide to Cook	grams/Liter	1.4	11.1	12%
Particulate Matter to Cook	mg/Liter	36.2	472.6	8%

Discussion of Performance

Lab tests indicated that the institutional barrel stove could save 73% of the fuel used by the open fire. The Controlled Cooking Test indicated only a 59% savings. Why the difference?

Lab tests (the WBT) are used as a design tool to determine what the stove itself is capable of when carefully operated under controlled laboratory conditions. It is not predictive of actual fuel use. The Field test (the CCT) is used to get an estimate of how the stove might actually perform when used by real people preparing real food and using locally available fuels. True measurement of fuel savings requires a third test (the Kitchen Performance Test) which measures actual fuel use in many households over a long time period. The KPT was not performed in this study.

Three stone fires in schools cooking beans

The WBT in the lab incorporates a high power phase (bringing water to boil) and a low power phase (simmering water for 45 minutes at just under boiling temperature) to approximate a common cooking procedure (like cooking beans or rice).

The actual procedure for cooking beans in northern Uganda uses high power only. There is no simmering period. Beans are boiled vigorously for the entire time they are cooking. No attempt to alter this practice was made during Freda's cooking tests. After the completion of the CCT tests however, Freda was very surprised to learn that the temperature at a roiling boil (94°C) was no hotter than the temperature at simmer.

Lids were observed being used in about half the cases where beans were cooked. Freda chose to use a lid both for the institutional stove and the three stone fire. When lids were used, steam was observed escaping around the lid almost continuously. In the CCT, the extra fuel required to produce this steam at prolonged high power helps explain the difference in fuel consumption between the WBT and the CCT.

It should be noted that the institutional barrel stove had better heat transfer and therefore boiled off more water than the open fire. Beans cooked with the institutional stove were less "watery" than with the open fire and therefore weighed less. If the weight of finished beans had been adjusted for the difference in water, the calculation of specific consumption would have shown closer agreement between the WBT and the CCT.

The institutional barrel stove cooked beans in 2 hours and 9 minutes (average) vs. 3 hours and 41 minutes for the open fire. The time required to reach a boil with the institutional stove (16 minutes) was typically about half of that required with the open fire (31 minutes).

Cost of Manufacture vs. Cost Estimates

Costs for Institutional Stove from 200 Liter Barrel

	(retail-USA) actual cost	**(India)** estimated cost	**(Uganda)** actual cost	basic model **Ceramic CC (Uganda)** estimated cost
Combustion chamber (imported to area)				
309 steel (heat resistant)	$28.62	$20.58	$28.62	$1.61
Labor (fabrication)	$35.75	$3.25	$35.75	$0.00
Other Materials (obtained locally)				
20 Ltr. (5 gal.) bucket	$1.00	$0.50	$7.49	$7.49
insulation (vermiculite)	$2.00	$1.00	$1.01	$0.00
200 Ltr Barrel (55 gal.)	$6.00	$6.00	$25.36	$25.36
Skirt (from half of barrel)	$3.00	$3.00	$12.68	$12.68
bolts (14 each 5/16")	$3.42	$1.71	$3.34	$3.34
nuts (22 each 5/16")	$1.54	$0.77	$1.15	$1.15
washers (32 each 5/16")	$1.92	$0.96	$0.81	$0.81
spacer pipes (18" of 1/2")	$0.37	$0.19	$0.29	$0.29
chimney brace	$3.00		$0.00	$0.00
screws (24 each #8)	$1.44	$0.72	$2.88	$2.88
elbow for chimney	$4.54	$2.27	$0.00	$0.00
chimney (3 sections -9')	$18.03	$9.02	$7.20	$7.20
Subtotal	**$110.63**	**$49.96**	**$126.59**	**$62.82**
handles				$2.59
Pot (60 liters)	**$65.90**	**$32.95**	**$69.16**	**$17.00**
Assembly Labor (estimated 16 hrs.)	**$400.00**	**$6.50**	**$17.29**	**$17.29**
Total	**$576.53**	**$89.41**	**$213.05**	**$97.12**

12 combustion chambers made of three different grades of heat resistant steel were brought from the United States for use in the stoves. 309 stainless (rated for 1050ºC) and 321 stainless (rated for 850ºC) were used for 4 combustion chambers each fabricated by a sheet metal shop in Oregon. 310 stainless (rated for 1100ºC) was used for four slightly larger combustion chambers with grates which were made in cooperation with Dr.Brian Willson and his staff at Colorado State University. The cost of these metal

prototype combustion chambers was high (about $55 US) and should not be viewed as representative.

Locally made insulative bricks from a nearby stove project (6 brick rocket stoves) were not immediately available. The manufacture of 4 stoves utilizing this type of combustion chamber had to be delayed until more bricks were fired. If this type of combustion chamber proves durable it should be much cheaper (about $1.61 US) than metal versions.

Another type of ceramic combustion chamber made in Kampala (UCODEA – GTZ) was considered but not tried. These one piece units were designed for smaller saucepans and are not suitable for large institutional pots. A larger version of this same combustion chamber might be another inexpensive option.

All other components for the stoves were obtained locally. Metal parts in general were found to be more expensive than anticipated.

Pots (called "saucepans" in Uganda) were difficult to obtain in quantity and cost $70 to $110 US for 50 liter aluminum versions imported from India. Larger (100 liter) pots and stainless steel pots of any size were unavailable. 70 liter 1.5mm thick stainless steel pots could be fabricated in Kampala for about $145 US each.

A wide shallow "saucepan" with a capacity of 46 liters was available in local markets for about $ 15 US. These thin aluminum pans were fitted with handles and used in some of the institutional stoves.

Used oil drums (55 gal.) were available for $25 each (vs. $6 in Oregon). Many of these drums were trucked in from Kenya so much of the increased cost was transportation. Care must be taken to ensure that the used drums did not previously contain toxic chemicals.

The institutional barrel stove was designed to incorporate a 20 liter World Food Program cooking oil can to hold insulation around the combustion chamber. Many of these cans are supplied to the IDP camps around Gulu. It was surprisingly difficult and expensive to obtain good cans. We had estimated that they could be bought for less than a dollar but we ended up paying $7 ½ dollars for each one. Most of the available cans had large holes punched in the tops (which made them unusable for us). WFP cans are also scarce because they are a prime source of tin for local sheet metal workers. We found that it was less expensive to have a new "can" fabricated from other materials than to try to buy "good" WFP cans.

20 liter WFP can being made into a combustion chamber

Other uses for WFP cans

Making chimneys

Chimney sections 2 meters long and 15cm in diameter were made by a local tinsmith. Local craftsmen are amazingly skilled and resourceful. Cost was about $4.60 for materials and $2.60 for labor.

Elbows and braces for the chimneys were fabricated from the scrap end which had been cut out of the 55 gallon drums. This process was labor intensive and used about a third of the time required to build the stove. Ready made elbows were not available.

Vermiculite for insulating the combustion chambers was available in Kampala at Canmin Inc. for about a dollar per stove. Wood ash is also widely available but must be gathered as it is becomes available. Most people discard their ash daily.

Payback time for the institutional stove

No consideration is given to health benefits or time savings from using the institutional barrel stove.

The following assumptions are made in calculating payback time:

1. Cost of wood is the same as the selling price in the IDP camps. Large institutions may save money by purchasing larger quantities.
2. Cost of splitting wood is not considered. The observed practice with rocket stoves in other IDP camps is that people begin gathering wood of the appropriate size rather than splitting larger pieces.
3. Only one meal is prepared per day. If two or more meals are prepared per day the payback time decreases proportionally.
4. Basic model stove using ceramic combustion chamber and 46 liter "saucepan" is used.
5. Stove costs $100 US.

Cost of wood (Unyama camp) is 5500 Ush (Uganda shillings) = $3.17 US
Weight of wood 95.39 kilos

Cost per kilo = $0.0332 per kilo	
Wood used by Three Stone Fire per pot of beans	15.365 kilos
Wood used by Institutional Stove per pot of beans	5.476 kilos
Wood Savings per pot of beans	9.889 kilos
Cost savings per pot of beans	$0.328 US
Payback period is	305 days

Comments and Observations

When stoves were demonstrated at schools or hospitals, it was noted immediately that the stoves used less wood than the open fires or traditional stoves they were replacing. People tended to overestimate the fuel savings and guessed that the stoves saved 90% of the fuel rather than the more probable 75% to 50% savings.

People were impressed by the speed with which water was brought to a boil. The institutional barrel stove has very good heat transfer and brings water to a vigorous boil in less than one minute per liter of water. Some people believed that there had to be a larger fire concealed inside the barrel to provide all the heat.

Saving time was more important to cooks than saving money on fuel. Administrators and directors (who pay the bills) were more concerned with fuel savings.

The institutional barrel stove produces very little smoke once the combustion chamber is hot. Several people wondered "where does the smoke go?"

Cooks appreciated that the chimney removed flue gases from the cooking area and made cooking more pleasant. There was, however, little recognition that breathing smoke could be harmful to health. .

Demonstrating stoves at Laroo Boarding School for War Affected Children

Projected cost of the stove did not seem to discourage prospective buyers. Often the pot would cost more than the stove when larger (100 liter) pots were considered. Other slightly larger (165 liter) stoves from Kampala were priced at $900 US per stove. There were many requests for a smaller version of the institutional barrel stove for use in the home.

Greater savings in fuel consumption are possible if people are willing to use stoves at low power for prolonged cooking.

Feeding center for children in Coope IDP Camp

These stoves will be monitored every three to six months to see if they are still being used and if parts are failing. Initial enthusiasm for the institutional barrel stove may fade if maintenance or design problems become apparent. Initial feedback from Gulu Regional Referral Hospital was that their stove was in regular use and has replaced three other stoves which were being used to cook for the hospital.

Continued monitoring and periodic testing are required for any successful stove project.

Damon Ogle / Aprovecho Research Center
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