Aprovecho Research Center
Advanced Studies in Appropriate Technology

INSTITUTIONAL BARREL STOVES IN NORTHERN UGANDA

SUMMARY

Twelve Institutional Barrel Stoves were built in Gulu, Uganda, and donated to schools, hospitals and feeding centers. This project was founded by Damon Ogle, the designer of the stove, and was implemented in partnership with Aprovecho Research Center and AIDAfrica. Funding for the project has been provided in large part by Damon Ogle personally, with additional resources made available by Aprovecho and AIDAfrica. The objective of this project was to monitor the stoves while in actual use in the field for performance, durability of components and possible design modifications. Controlled Cooking Tests were performed comparing the results of actual cooking practices with Water Boiling Tests conducted in the laboratory. Costs for parts and labor for fabricating the stoves were recorded and compared with estimates for manufacturing the same stove in the United States and India. Test results showed a significant reduction in fuel use and time to cook compared with the traditional open fire. Initial acceptance of the stove by the intended users seemed positive. Monitoring the durability of components is ongoing. Mr. Ogle intends to expand this project by disseminating and monitoring an additional 50 stoves.

End-user area: Other
Target audience: Schools, hospitals and feeding centers
Technical: Energy efficiency, Biomass

INTRODUCTION

This project was founded in Gulu, Uganda. Conditions in the region are dire. It is estimated that approximately 1,000,000 refugees live in Internally Displaced Persons (IDP) Camps. Fuel wood is scarce and the collection of it is dangerous and time-consuming. The object of this project was to install twelve Institutional Barrel Stoves in order to obtain data on stove performance, durability of components and possible design modifications.

OBJECTIVES

The objective of this project is to introduce the Institutional Barrel Stove to hospitals, schools and feeding centers in order to improve energy efficiency, specifically to decrease the amount of biomass used for specific cooking tasks.

A major element in the study is to monitor the stoves while in actual use in the field for performance, durability of components and possible design modifications. Controlled Cooking Tests were performed comparing the results of actual cooking practices with Water Boiling Tests conducted in the laboratory. Costs or parts and labor for fabricating the stoves were recorded and compared with estimates for manufacturing the same stove in the United States and India.

METHODOLOGY

The Water Boiling Test (WBT) and Controlled Cooking Test (CCT) protocols developed by the University of California at Berkeley (with assistance from Aprovecho Research Center) were used to evaluate fuel use and time to cook. The WBT is a test which measures the performance of the stove under carefully controlled laboratory conditions. The WBT is a useful design tool but is not predictive of actual performance in the field. The CCT uses local recipes, fuels and cooks to compare one stove to another in the field. The CCT is reality check for actual stove performance and acceptability by the intended users. Both tests showed a statistically significant reduction in fuel use and time to cook between the institutional stove and the traditional three stone fire. Full descriptions of the testing procedures are available on the Aprovecho website at http://www.aprovecho.org/web-content/publications/pub2.htm

FINANCIAL RESOURCES AND PARTNERS

Project Manager: Damon Ogle is the Founder and Manager for the Institutional Barrel Stoves Project in Northern Uganda. The majority of the funding for this project, which includes travel and materials, has been donated by Mr. Ogle.

Project Support: Logistical support in Gulu has been generously provided by AIDAfrica, a non-profit corporation established and managed by Ken Goyer. Other support has been provided by Aprovecho Research Center of Cottage Grove, Oregon.

FINDINGS / OUTCOMES

When the institutional stoves were demonstrated at schools and hospitals, it was immediately apparent that fuel use was drastically reduced when compared to the open fire or traditional stoves. Cooks tended to overestimate the fuel savings, guessing the stoves saved 90% of the fuel, rather than the more probable 50 – 75% savings.

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%

People were also 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 sufficient heat to warrant performance. It was interesting that saving time was more important to the cooks than saving money on fuel, while administrators and directors (who pay the bills) were more concerned with fuel savings. Cooks appreciated that the chimney removed flue gases from the cooking area and made cooking more pleasant. However, there was little recognition that smoke inhalation could be harmful to health.

The 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.

Costs for Institutional Stove from 200 Liter Barrel

Combustion chamber (imported to area)	**(retail-USA)** actual cost	**(India)** estimated cost	**(Uganda)** actual cost	basic model **Ceramic CC (Uganda)** estimated cost
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**

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

OTHER BENEFITS

Health benefits will accrue from the use of the Institutional Barrel Stove due the decrease in the amount of smoke inhaled by the cook. Measurement of the extent of these benefits is outside of the scope of this project.

Climate changing emissions will be reduced by the decrease in fuel use and the cleaner combustion obtained in the insulated "rocket" combustion chamber. Lab tests (the WBT) included measurements of CO2, CO, and other Kyoto Protocol "greenhouse gases" which were greatly reduced in the Institutional stove. More significantly, "black" elemental particulate matter (not one of the Kyoto gases) was also greatly reduced. Recent research by Dr. Tami Bond and others indicates that black carbon particles produced by traditional stoves and other biomass burning are a large contributing factor to global warming and glacier melting worldwide.

LESSONS LEARNED AND REPEATABILITY

Two years after the distribution of the stoves, the project was revisited to try to determine the durability of different types of materials used in combustion chambers and identify design flaws. Stoves which were broken were photographed and disassembled and the critical pieces were brought back to Aprovecho Research Center for study. Of the three types of heat resistant metal used (321, 309and 310 stainless) all showed little or no corrosion or perforation. All did show considerable warping due to repeated heating and cooling but this did harm their performance. The stove made from 310 SS was still in use in a hospital and was photographed but not dismantled. The other two metals were of a different configuration and failed because of a design flaw which allowed the surrounding insulation to escape. Most stoves failed because the insulation container (a USAID 20 liter cooking oil can) burned out when the insulation disappeared. The next phase of the project (50 stoves) will use an altered design which should eliminate these problems.

Cost of metals and quality control were problems in Uganda. It may be better (and cheaper) to make the stoves outside of Uganda and ship the finished product in. Logistics (keeping a vehicle running) is always difficult in developing countries.

Attempts had been made to repair the combustion chambers of some of the stoves which had broken due to design flaws. This indicates that the stoves were accepted and valued by the users. Two of the stoves had simply disappeared (probably stolen). Perversely, this is probably a good sign as the stoves were valued enough to take the whole thing. Often in institutional stove projects, only the pot is taken which then makes the stove useless.

Personal testimonials ("everybody loves the stove and it saves 90% of the fuel! ") should be discounted as unreliable. Continued testing and monitoring of durability and use is critical to a successful stove project.

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