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Highlights of the ETHOS Summer Stove Camp, 2008

August 4-8

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Thirty one participants came to the new Aprovecho campus at Fred's Island to spend a week investigating biomass cooking stoves. The themes this year were 1.) To develop a shared understanding of heat transfer and 2.) To build and test prototypes of most effective refugee stoves making posho. The Posho Award plus a cash prize of $250 went to the most successful prototypes and inventors.

The Camp was a lot of fun. Many participants camped on the lawns near the river. We cooked dinners on wood burning stoves from many countries. The Posho Balls, deep fried and coated in butter and honey, went down very sweetly. The 'Fred's Island Democracy Choir' entertained in the huge auditorium and there was a more-than-credible amount of sing-along and audience participation. The 4 acre wooded campus and new larger lab with classroom and guest room, the new emission equipment, etc. made Stove Camp pleasant. But, it was the energy and inventiveness of the participants that made Stove Camp 2008 a success.

Some of the topics for classes and discussion included:

- Defining our task
- Stove Testing
- Heat Transfer Efficiency
- Combustion Efficiency
- Global Warming/Carbon Credits
- Stoves and Health

A major focus of this year's camp was designing stoves for refugees in Darfur and Uganda. Since it was location-specific, the testing focused on the CCT rather than the lab-based WBT. Teams tested their stoves by making posho, in this case white corn meal stirred into boiling water, and the cooks stirred until the posho had a thick consistency.

Criteria for Refugee/IDP Stoves

Pam Baldinger of USAID has been incredibly helpful and sent her criteria for a successful stove:

> "Why people like stoves (in no particular order):
> - Fuel savings (obviously)
> - Time savings (i.e., cooks faster)
> - Less smoke
> - Less risk of fire and burns (very important--we've tested 2 metal stoves and they've both been problematic on this score)
> - Ease of use (in Darfur, this includes stability during stirring, which is a problem for many stoves)
> - Ease of mobility
> - Ease of maintenance/durability (the less maintenance required, the better)
> - Size/appearance (IDP/refugee homes are small and tightly packed)
> - Cost
> - Taste (there were some complaints about different taste of food when moving from open fire to metal in particular)
> - Ability to accommodate different pot sizes
> - Weather/How long does it take mud to dry
> - How easy/difficult is it to light/control a fire in windy conditions (particularly important in Darfur)"

Results of CCT: Three-Stone Fire

It is extremely important to note that it was everyone's first time cooking posho on the three stone fire. This was the first time cooking on a three-stone fire for many, and the first time cooking under experimental conditions for most. Also, only one test per group was completed. So, the results are not predictive or statistically significant. But we learned a lot!

Three-Stone CCT

1. CCT results: Stove 1	units	Test 1	Test 2	Test 3	Test 4	Test 5	Test 6	Average	COV
Total weight of food cooked	g	1,513	1,475	1,484	1458	1520	1516	1,494	2%
Weight of char remaining	g	-	-	-	0	0	0		
Equivalent dry wood consumed	g	651	794	780	518	372	501	**603**	28%
Specific fuel consumption	g/kg	430	538	525	355	245	330	**404**	29%
Total cooking time	min	25	20	23	21	17	23	**22**	13%

NOTE: We chose not to measure the charcoal remaining, because attendees who had been to the area thought that it was not common practice to save and reuse or sell charcoal.

Measuring the performance of the three stone fire usually results in a big difference between best and worst scores. In this case, Ken Goyer and team used 372 grams to boil water and cook the posho. At the other end of the scale, two groups used 780 and 795 grams to do the same thing. We supposed that expert fire makers, who walk ten miles to get wood for cooking, would be careful and make fuel efficient fires.

How is Stove Improvement Proven?

A familiar disagreement can often be overheard at stove gatherings. The 'scientist' reports small differences in fuel use between the new and traditional stoves. The in-field worker says that their mud stoves save half the wood. The in-field worker has experienced countless times that the cooks who use the new stoves are delighted. How is stove performance proven?

The Kitchen Performance Test is included with the Water Boiling Test and the Controlled Cooking Test in "Testing the Efficiency of Wood-Burning Cookstoves: International Standards" (VITA, 1985). The following is taken from the book.

The three tests have different uses. The Water Boiling Test was designed "to measure how much wood is used to boil water under fixed conditions. This is a laboratory test, to be done both at full heat and at a lower "simmering" level to replicate the two most common cooking tasks." While it does not necessarily predict actual stove performance when cooking food, it is important for the comparison of stove performance under controlled conditions with few cultural variables."

“A Kitchen performance test is used to measure how much fuel is used per person in actual households when cooking with a traditional stove, and when using a new stove. The tester simply measures how much wood the family has at the beginning and at the end of each testing period.”

“A controlled cooking test serves as a bridge between the water boiling test and the kitchen performance tests. Local cooks prepare pre-determined meals in a specified way, using both traditional and experimental stoves.”

The International Standard Tests were revised for use by the Shell Foundation under the direction of Dr. Kirk Smith at the University of California at Berkeley in 2003.

The Kitchen Performance Test is the most reliable method to determine stove performance in the field. The Water Boiling Test is designed to teach the experimenter how stoves can save wood and reduce emissions and how the stove prototype can be technically optimized. The Controlled Cooking Test gets closer to in field use but, when watched, cooks may change their behaviors. The best measure is a kitchen survey where the influence of the tester is minimized.

Unfortunately, the Kitchen Performance Test has rarely been done. In-field surveys can be difficult for a host of reasons, especially in dangerous situations like Darfur. Does the small fuel entrance in a stove and protection from the wind result in one third to one half savings of fuel as estimated in a literature review in the Appropriate Technology Sourcebook (1993)? Can WBT and CCT findings be used to predict savings for whole regions? Or, as recommended, should a KPT be done?

When asked, I cannot truthfully say what kind of improved cook stove is needed to save 1/3 to ½ the fuel in real life situations.

Carbon credit financing now requires a rigorously conducted KPT to establish fuel savings. Many kitchen surveys should be done in the next few years. Hopefully, the kitchen tests will inform stakeholders about what kinds of stoves are needed to save 30%-50% of fuel: the minimum expectation of most funders.

The stoves at Stove Camp, when tested with a CCT, seemed to be capable of cooking food with a lot less wood. Some stoves used less than 50% of the fuel consumed by the most efficient three stone fire test. These type of stoves, that used skirts around the pot, seemed to perform well even when made from sand and clay. Answering the question of whether stoves need to use skirts to save large amounts of fuel should be possible when the carbon credit kitchen surveys are completed. Until then, the familiar disagreements will probably continue…

Stoves Were Designed, Built, and Tested at Stove Camp

After discussing what cooks like about stoves, and what is known about heat transfer and combustion efficiency, the teams tried to design some stoves that might work in Darfur. This was an exercise, and, of course, designing stoves for a particular region has to involve working directly with the cooks. We started by acknowledging that the carefully tended three-stone fire is a tough opponent, and that stoves must please the cook to be effective. At best, stoves made at Stove Camp can indicate the strategies that save wood and reduce emissions. We hope that the winning designs can go into the IDP camps in Uganda, where we have contacts, for necessary development with input from local cooks.

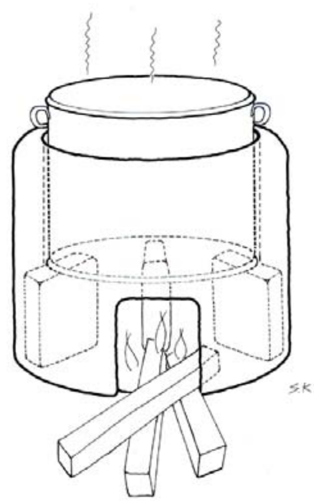
The good ol' skirt stove designed by our hero Sam Baldwin. Made adjustable by John Page and crew!

Dale's prototype perforated finned pot. It's not pretty yet, but it works!!!!!! Fins can be decorative and functional we feel…

A mud/cement skirt stove designed around the testing pot with 10mm gap. This one was named the Volcano and Bill Martin introduced his team's entry to the voters while Damon Ogle, foreground, grins.

One of Paul Anderson's gasifier stove setups, with interchangeable ceramic and fan-assisted combustion chambers.

Damon's10L pot sunken pot Rocket stove with chimney works with both pot and griddle. An internal skirt makes this stove fuel efficient.



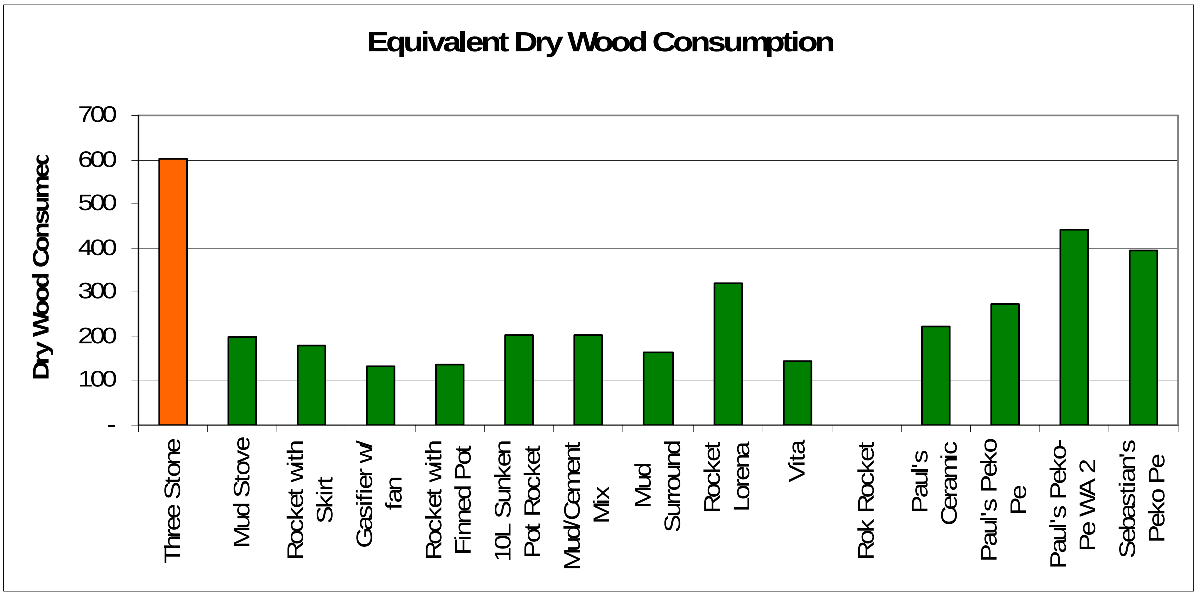
The mud stove version of Sam Baldwin's skirt stove. Even when the stove was made from 60% sand and 40% clay without added insulation it saved fuel.

Fuel Use and Emissions of Prototype Stoves

Improved Stove CCT		Mud Stove	China Rocket with Skirt	Gasifier w/ fan	China Rocket with Finned Pot	10L Sunken Pot Rocket with Chimney	Mud/Cement Mix	Mud Surround Sawdust Mix	Rocket Lorena	Vita	Rok Rocket	Paul's Ceramic Gasifier	Paul's Peko Pe	Paul's Peko-Pe WA 2	Sebastian's Peko Pe
Total weight of food cooked	g	1437	1575	1624	1553	1535	1609	1685	1494	1618	N/A	1517	1588	1428	1430
Weight of char remaining	g	-													
Equivalent dry wood consumed	g	200	178	133	138	205	203	166	321	145	N/A	221	275	443	395
Specific fuel consumption	g/kg	139	113	82	89	134	126	99	215	89	N/A	146	173	310	276
Total cooking time	min	19	23	17	20	17	26	27	36	19	N/A	18	17	17	17

Total Emissions	Three Stone	Mud Stove	China Rocket with Skirt	Gasifier w/ fan	China Rocket with Finned Pot	10L Sunken Pot Rocket with Chimney	Mud/Cement Mix	Mud Surround Sawdust Mix	Rocket Lorena	Vita	Rok Rocket	Paul's Ceramic Gasifier	Paul's Peko Pe	Paul's Peko-Pe WA 2	Sebastian's Peko Pe
CO (g)	**37**		7.2		6.8	8.0	10.9			7.6		10.9	8.1	1.2	0.5
PM (mg)	**2282**		476		399	738	586			624		764	166	13	25
IAP/Exposure															
Average CO (ppm)	3.2							1.0			0.9				
Average PM (ug/m3)	913							485			180				

Total emissions were measured using the portable emissions measurement system (PEMS) available from Aprovecho. IAP Exposure was measured by a test cook wearing the new Aprovecho IAP meter in backpack with sampling tube near their mouth/nose for exposure measurement. The IAP/Exposure results were measured outside.



As can be seen, many stoves used significantly less than 372 grams, the lowest score from the three stone fire. Increasing the amount of heat that gets into the pot of posho reduces the fuel used when cooking. The most fuel efficient stoves forced the hot gases to scrape against both the bottom and sides of the pot. The mantra that Bill Martin developed at Stove Camp 2008 was "MIND THE GAP!"

The teams that paid attention to increasing heat transfer efficiency created inexpensive stoves that dramatically reduced fuel use even when they were made from clay and sand.

Heat Transfer Efficiency (HTE) into the pot can be significantly improved by:

Increasing the temperature difference between the flue gases and the outer surface of the pot.

Optimizing the proximity of the flue gases passing by the pot.

Increasing the velocity of the flue gases reduces the boundary layer.

Increasing the area of the pot exposed to the hot gases.

Increase Radiation.

(Look for Dr. Dale Andreatta's lecture on HTE soon to be on the Aprovecho web site: www.aprovecho.org)

Stove Scores

Since we had a list of criteria for the IDP stoves, we thought that the stoves in the competition should receive a quantitative score based on performance in each category. The whole group scored all stoves with a weight of 0-10 given to each category.

Category	Weight/Factor	Three Stone	Mud Skirt Stove	China Rocket with Skirt	Paul's Gasifier w/ fan	Dale's Finned Pot	Mud/Cement Skirt Stove	Mud Skirt Stove Sawdust Mix	Rocket Lorenaw/high mass skirt	Sheet Metal Skirt Stove	Paul's Ceramic Gasifier
Fuel Use	10	0	7	9	10	10	7	7	4	10	4
Emissions	8	0	5	8	9	8	7	7	10	7	4
Time	10	7	9	7	10	10	2	2	1	7	9
Fire and Burns	10	0	10	7	5	9	10	10	10	3	7
Ease of Use	10	6	10	7	6	9	10	10	10	5	6
Mobility	5	10	9	10	2	10	9	9	10	10	1
Maintenance	8	10	10	9	5	7	10	10	10	3	6
Appearance	1	10	10	10	6	2	10	10	10	10	6
Cost	8	10	10	8	1	9	10	10	9	8	7
Pot Sizes	10	10	3	8	8	6	3	3	3	8	8
Taste	1	10	10	10	10	10	10	10	10	10	10
Weather/Dry Time	2	10	5	10	10	10	5	5	5	10	10
Wind	5	2	10	10	10	10	10	10	10	10	10
SUM		850	1080	1130	920	1100	1030	1030	1020	1010	880

Notice on how many categories the three-stone scores a 10……..

The Two-Door China Rocket Stove with skirt received the highest overall score, but it was not officially in the competition. (The Aprovecho staff decided that we had too much of a home field advantage. But we agree with the appreciation given to the China Rocket stove.) The next highest score was the prototype finned concept pot invented by Dr. Dale Andreatta, which was tested on the Chinese Rocket Stove.

And the Posho Award goes to………..

Results showed a close race between the mud stoves and the finned pot. The group decided that the mud skirt stoves, with various mixtures of inexpensive sand, clay, sawdust, and cement, made by three groups had won the monetary prize. The prize money was then unanimously donated to a woman's organization in an IDP camp in Uganda.

The framed Posho Award went to Dale Andreatta for his amazing work with finned pots, which may be able to save 50% of the fuel without changing the stove. Congratulations go to Dr. Dale Andreatta for his tireless work helping humanity! Dale is one of our true a heroes, just like Baldwin.

Other Exciting Discoveries:

The Finned Pot

Further WBT testing of the finned pot on the China Two-Door Rocket stove (without skirt) showed that the finned pot saved 46% of the fuel but produced about the same amount of emissions. This suggests that the emission factors are higher in this particular preliminary design, but fuel savings are substantial. The fins were added to the standard WBT pot.

Five Fan Stoves

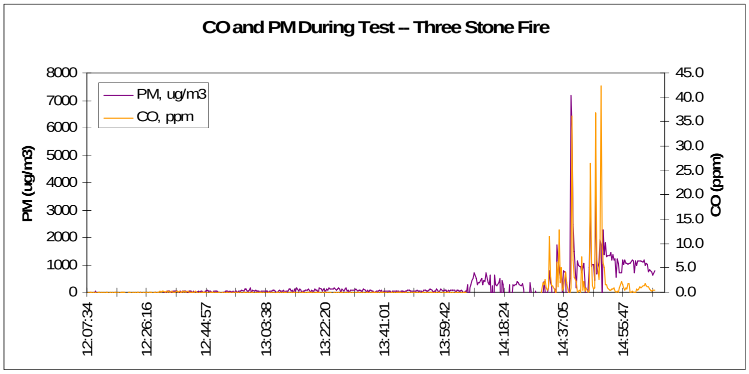
Five years ago, feasible fan stoves were just a glimmer in the eye of Tom Reed, the father of the fan stove movement. This week we had five fan-assisted stoves at camp! Pictured here are the Philips stove, The BP stove, Paul Anderson’s fan stove, Tom Reed/Wood Gas Fan stove, and Aprovecho’s patented side feed fan Rocket Stove. All seemed to work quite well and should be attractive to different markets. This has been an exciting development over the past few years. Fan stoves can be as clean burning as some liquid fuels.

IAP Backpack

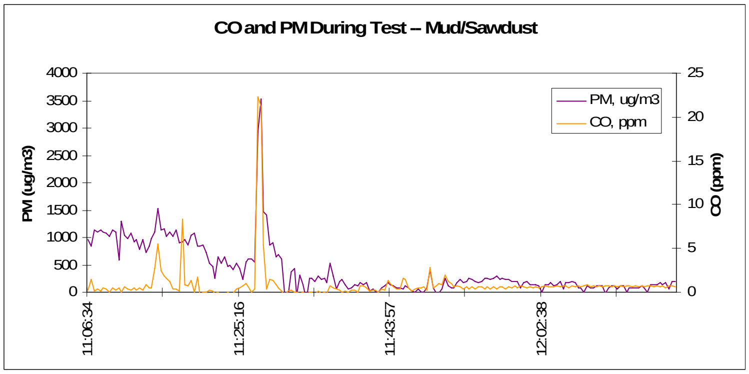
Aprovecho has recently developed a method for measuring the IAP levels to which the cook is exposed – by placing our specially-designed IAP meter in a backpack with a sampling tube over the shoulder near the mouth/nose of the user. In this way, exposure levels can be measured, no matter where cooking occurs.

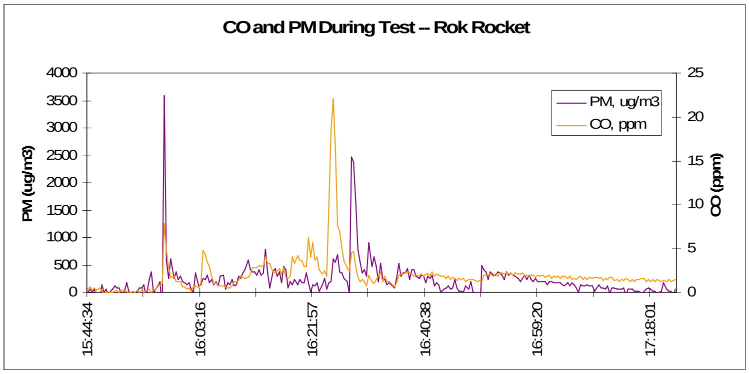
Our dear friend Christina wears the IAP meter during an ARECOP workshop in Indonesia.

The following data was recorded while campers cooked posho outside:



In this graph, the IAP backpack was monitoring for 2 hours before the test fires were started.





It's important to measure what is ingested by the cook to know if interventions are helping.

Further Information

The details of classes, handouts, data, and participants can be found on the Aprovecho website at http://www.aprovecho.org/web-content/publications/publications.html
Photos can be found at http://picasaweb.google.com/aproresearch

Fred's Island

Thanks to everyone for a wonderful week. Special thanks go out to Fred who invented his wonderful Island. Hope to see you next year!

~Dean, Nordica, Damon, Sandra, John, Sebastian, Ken, Larry and the whole far flung Aprovecho Family