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Summary of ETHOS Stove Camp, August 3-7, 2009

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Forty three folks attended Stove Camp this year coming from as far away as Norway, Germany, Honduras, and Mexico. Some people were too busy making stoves to be in the official photo. Paal Wendelbo, winner of the $250 prize for most interesting development, is the white haired gentleman two spaces to Dean's left. The theme this year constellated around health issues. You can see the presentations and results from Stove Camp by visiting www.aprovecho.org/lab/index.php.

Stove Camp featured many experiments. We set up a Test Kitchen, in which stoves were tested, making posho (African corn meal mush). Particulate Matter and Carbon monoxide were recorded in both the room air and at the nose/mouth of the cook. We also used a RAD 57 from Masimo to non-invasively measure levels of CO in the cook's blood before and after cooking. Stoves were also tested under the emissions hood, and practice WBTs were run without emissions measurements. Peter Scott and Dr. Andreatta were successful in creating an aluminum mitad with even temperatures for making injira. Reports follow!

Day to Day Activities

We discussed objectives, experiments, and the emissions equipment. We learned about the RAD 57 from Jennifer and began a series of three discussions on health, testing, benchmarks, and Gold Standard verifications. Hopefully all these types of testing will improve stoves and elevate our successes.

We had a great Bar-B-Que welcome dinner followed by Celtic/Americana music from the house band "Under the Trestle".

We learned design principles for chimney stoves, had a class on air exchanges, emission levels, exposure, and health by Nordica. She also gave an overview of protecting Human Subjects in experiments as required by international research standards. We started building $25 chimney stoves developed by Dr Larry Winiarski and Damon Ogle that reduce IAP, fuel used to cook, and climate change.

We discussed Global Warming, Heat Transfer Efficiency, and heard presentations from group members and built and tested stoves!

In addition to the daily activities, several experiments were ongoing.

Results of testing:

Four sets of experiments were carried out during camp:

1. The Jiffy Pop Experiment

To kick off the camp, we thought everyone should pick a stove from the museum and try cooking something with it. What to cook? Jiffy pop popcorn! We had a race to see who could cook the popcorn the fastest, using the least fuel, and produce the best tasting

popcorn. It was a bit chaotic and people had never run the stoves before, so the test was unscientific; a lot of popcorn was burnt, but here are the results:

Stove	Team	Time	Fuel		Taste Test
TLUD	Paul	2.5	N/A		Good
India Rocket	Elder, Victor, Ivan	4		70	Smoky
Philips Stove	Jacob, Laura, Burkhard	4.5	N/A		Good
Winiarski Mud Rocket	Christa, Damon	5.5		112	N/A
Tom Reed	Flip, David	6.5		148	Good
StoveTec 1-Door	7-Pound Salad	7.75		180	Great
Haiti Rocket Stove	Flip, Jon	N/A	N/A		N/A
Anila	Art, Scott, Eric	N/A	N/A		N/A

2. The Test Kitchen

The WHO health guidelines for PM are 75ug/m3 for 24 hour-average exposure. For CO the one hour limit is 30g/m3 and 10g/m3 for 8 hours of exposure.

In an effort to generate data about the link between improved stoves and improved health, stoves were tested in the kitchen while measuring time/fuel use, Indoor Air Quality of CO and PM in the room, exposure to the cook of CO and PM, and the CO absorption in the blood of the cook using the RAD 57. Unfortunately, the RAD 57 has large margins of error below 6% so results are not statistically significant at the low levels we achieved to protect the health of the cook.

The stoves were tested three times cooking posho in the new Test Kitchen except for Paul's TLUD and the Haiti Rocket which were tested once. The TLUD and the Fan Stove were not operated under the natural draft chimney. They were run in the room air with a hole in the roof and the door open. The other stoves were run under a natural draft hood with a three foot long eight inch chimney patterned after more successful hoods developed by Aprovecho, with all other openings shut.

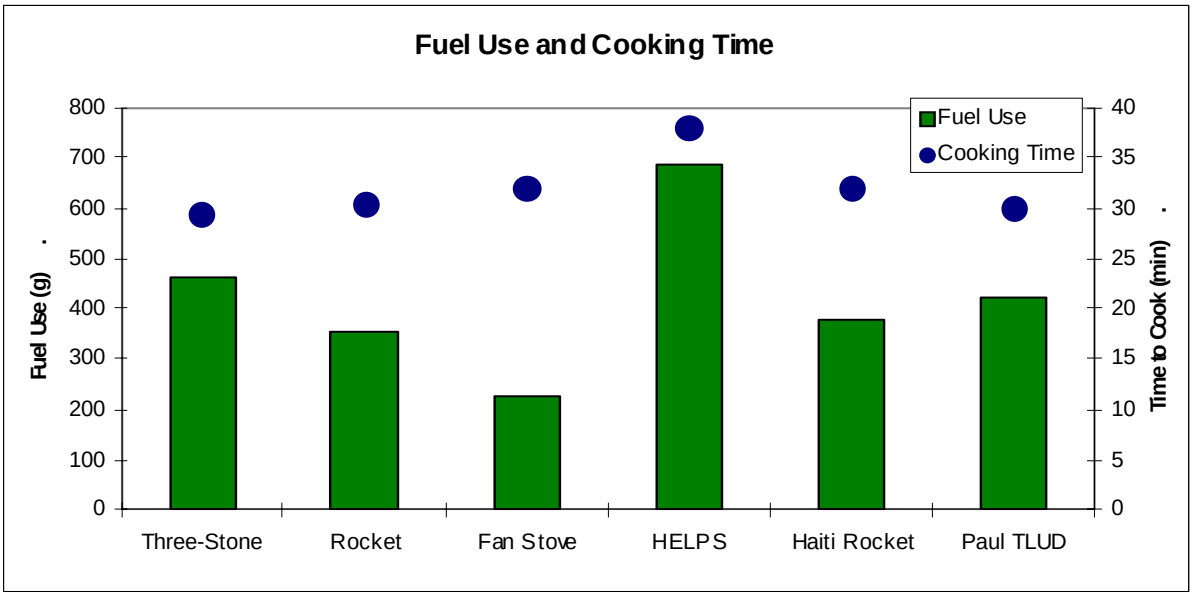
Fuel use followed previous patterns.

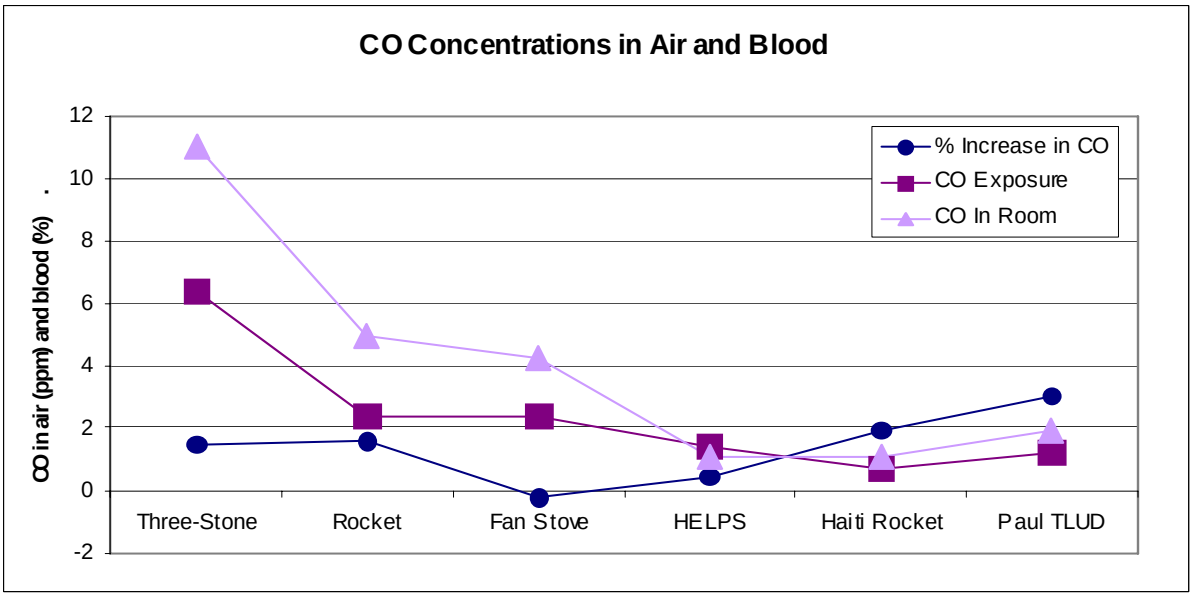
It was interesting to see that CO concentrations in the cook's blood were not very elevated. Again, the RAD 57 results are not significant and all results, except perhaps the open fire, have to be interpreted as equal. The CO at the nose and mouth of the cook and the CO measured above the opening to the natural draft hood seemed to be correlated and again, both were low and perhaps in the "healthy" range.

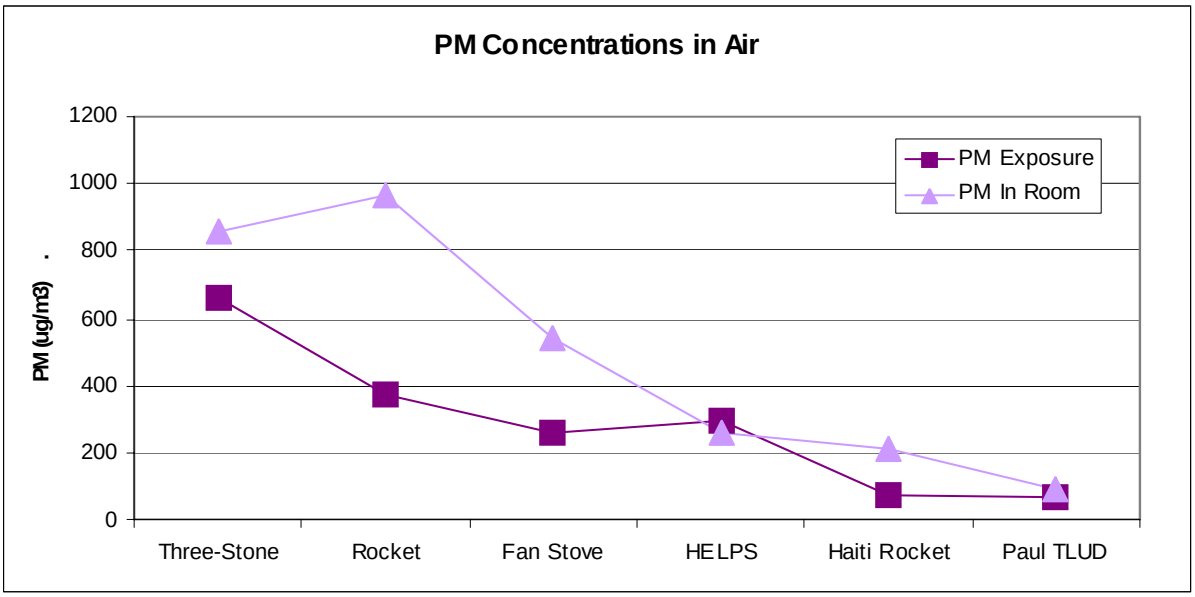
The concentrations at the nose and mouth of the cook for PM ranged from 400 ug/m3 to around 1000 ug/m3 averages during the approximately 30 minute cooking time. Paul Anderson's TLUD was very low in PM and was operated in the room air with door open and a hole in the roof. The fan stove was also cooking food in the room with a hole in the roof and with the door open. The other stoves, including a chimney stove, were operated

with all openings closed under the natural draft hood. If the stoves were used three times a day for 30 minutes all would just reach the "safe" level according to this brief lab study and the 24 hour WHO guidelines.

Aprovecho will continue these preliminary studies. Test Kitchen studies can be very helpful to gain an understanding of the relationship between stoves and air exchanges and then to help define parameters for useful and necessary field studies.







3. The participants stoves were tested under the PEMS

Testing for fuel use and emissions is essential to optimize stove design. Participants at camp were invited to have their stove tested using Aprovecho's emissions equipment.

The following table shows the overall results of the UCB revised Water Boiling Test with emissions. Note the benchmarks for each measure are in parentheses.

Standard Performance Measures		Christa Mud Rocket side air with skirt	Haiti Rocket	Haiti Rocket Retest	PekoPe	Multi Use Stove	Toucan Stove	TLUD
Fuel to Cook 5L (850/1500)	g	666.6	1046.4	809.1	768.8	2749.5	925.2	1075.7
CO to Cook 5L (20)	g	59.2	50.5	27.4	23.0	67.3	52.0	90.5
PM to Cook 5L (1500)	mg	1656.2	3267.8	3060.6	223.1	3191.6	2059.9	9904.4
Energy to Cook 5L (15,000/25,000)	kJ	12,839	20,153	15,582	14,807	52,954	17,818	20,718
Time to Boil	min	48.4	47.7	26.4	28.1	30.6	18.9	25.0
CO2 to Cook 5L	g	1307.7	1716.7	1395.5	708.6	843.8	1052.5	1098.4

Notice that the Haiti Rocket showed a lot of improvement in its second test. Several design problems were identified and corrected, and then the stove was retested. The benchmarks created by The Shell Foundation define improved stoves using measures in the lower ranges for fuel use, CO, and PM. Some of the stoves tested at Stove Camp were ok in one respect but too high on other measures. And while some stoves did well in the Test kitchen they showed different results under the hood. The remarkable stove in this group is the PekoPe which was remarkably clean burning with low fuel use.

4. **The sunken pot Dr. Larry Winiarski Rocket chimney stoves that were built by groups at Stove Camp, were tested using the WBT.**

(In the photo, Dean's wife Kim is boiling pasta while Burk stir-fries veggies from the Aprovecho farm on the China Rocket. We also enjoyed salmon with butter and capers.)

The WBT can also be done without emissions measurements. Nordica taught a class on the WBT and groups ran through the three parts of the test: Cold Start High Power, Hot Start High Power and Hot Start 45 Minute Simmer at Low Power. We've included a lot of numbers below to show the multi-faceted view created by the Excel spreadsheet data. The stoves were powerful influences that came within 3% for fuel use even though firepower varied from 12 kW to 4.7kW in the cold start of the tests.

Here are the results:

1. HIGH POWER TEST (COLD START)	units	Test 1	Test 2	Test 3	Average	St Dev	COV
Time to boil Pot # 1	min	10	26	17	17.7	8.0	45%
Temp-corrected time to boil Pot # 1	min	10	25	16	17.0	7.6	45%
Burning rate	g/min	37	15	20	23.9	12.0	50%
Thermal efficiency	%	24%	30%	32%	29%	4%	14%
Specific fuel consumption	g/liter	76	81	69	75.2	5.8	8%
Temp-corrected specific consumption	g/liter	74	77	66	72.4	5.6	8%
Temp-corrected specific energy cons.	kJ/liter	1,429	1,486	1,279	1397.9	107.2	8%
Firepower	watts	12,057	4,739	6,297	7698	3,854.7	50%

2. HIGH POWER TEST (HOT START)	units	Test 1	Test 2	Test 3	Average	St Dev	COV
Time to boil Pot # 1	min	11	15	13	13.0	2.0	15%
Temp-corrected time to boil Pot # 1	min	11	15	13	12.8	2.1	17%
Burning rate	g/min	24	18	25	22.4	3.6	16%
Thermal efficiency	%	34%	34%	33%	34%	1%	2%
Specific fuel consumption	g/liter	52	56	68	58.8	8.2	14%
Temp-corrected specific consumption	g/liter	51	56	66	57.7	7.7	13%
Temp-corrected specific energy cons.	kJ/liter	987	1,079	1,278	1114.6	148.8	13%
Firepower	watts	7,617	5,883	8,096	7199	1,164.4	16%

3. LOW POWER (SIMMER)	units	Test 1	Test 2	Test 3	Average	St Dev	COV
Burning rate	g/min	6	5	5	5.4	0.5	9%
Thermal efficiency	%	31%	26%	19%	25%	6%	25%
Specific fuel consumption	g/liter	63	52	54	56.0	6.0	11%
Temp-corrected specific energy cons.	kJ/liter	1,213	996	1,036	1081.6	115.9	11%
Firepower	watts	1,905	1,608	1,696	1736	152.8	9%
Turn down ratio	--	5.16	3.30	4.24	4.24	0.9	22%

BENCHMARK VALUES (for 5L)

Fuel Use Benchmark Value	g	627	590	599	605	19.3	3%
Energy Use Benchmark Value	kJ	12,106	11,390	11,571	11,689	372.6	3%

Stove Camp '09 was one of our best. We had great conversations, created interesting looks at stoves and health, and made better friends. The new four acre campus, next to the river, makes an idyllic setting and our 5,000 ft^2 building has plenty of room for this kind of event.

We are convinced that stoves and stovers are ready to meet the new definition in the Waxman-Markey Bill: 1.) 50% fuel reduction, 2.) 30% reduction in childhood pneumonia, 3.) 60% reduction in black carbon. Stoves may not be way ahead of the curve but I'm pretty sure that, with a little tuning, existing $10 stove designs can meet the suddenly more stringent requirements for stoves that also 4.) have to be liked by cooks, 5.) liked by funders, 6.) be safer, 7.) affordable, 8.) successfully marketed, and 9.) manufactured in the millions.

Dr. Dale Andreatta has a wonderfully dry sense of humor. I was listing the new definition for a $10 stove that it now has to protect health, the planet, and forests.

Dale added “And whales!” sotto voce from the corner.