

# Aprovecho Research Center

## Advanced Studies in Appropriate Technology Laboratory

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### U.S. EPA - Aprovecho Research Center CCT Training for Mexico, Honduras, El Salvador, and Guatemala July 27- August 2 2013 Mike Hatfield – ARC

#### Overview:

Late July 2013 Aprovecho Research Center (ARC) completed a third Controlled Cooking Test (CCT) training as a U.S. EPA funded training program. This work consisted of training stove factory owners and stove developers who are partners with StoveTeam International on the CCT. During this training a full CCT was conducted which gave a comparison in fuel use and emissions of the stove they are disseminating to the traditional stove. Therefore there were two goals of this training, (1) making sure the participants from the factories could conduct a CCT in the future, and (2) giving these stove disseminators emissions and fuel use report during a common cooking event.

The stove was tested using Aprovecho's Portable Emissions Measurement System (PEMS), in which real-time emissions of CO<sub>2</sub>, CO and PM<sub>TSP</sub> were recorded. The system also measured the flow rate of the diluted exhaust gases, enabling mass-based calculations of the emissions.

## Controlled Cooking Test (CCT) Training:

StoveTeam International is a U.S. based nonprofit organization that supports and partners with locally based stove factories in Mexico and Central America. These factories produce and sell a stove developed by StoveTeam called the Ecocina. While production and sales of the Ecocina comprise the majority of their business, these factories are also entrepreneurial businesses that work with a variety of stove designs. Often the owners reported coming across a new design. The value of the CCT is that it can quickly give these factories the ability to evaluate a new design for fuel use while at the same time getting feedback on a new stove design from a small sample of local cooks.

The Ecocina has been tested in the Aprovecho lab for fuel use and emissions with the WBT and in the field for fuel use with the KPT. This CCT will give accurate in-field results of both fuel use and emissions.

The CCT gives a comparison between two stoves. It gives results for the time it takes to cook a given meal and fuel consumption. By adding an emissions hood, results for CO and PM emissions may be added to the results. The comparison is given in percent reduction between the two stoves. As an important aspect of the CCT is to use regional wood, pots, food, and cooking practices, results from a CCT only give results that can be used to compare stoves in that particular region.

In determining the cooking task for a CCT, it is important to pick a meal that represents how the stove will be used in the field. Depending on the amount of time that is available for a particular study, it is also important to pick a meal that can be repeated the 18 times necessary for a complete study. In the case of this study it was determined that a meal between 1 ½ - 2 hours would allow for the 18 tests plus some repeats if needed in the allotted time.

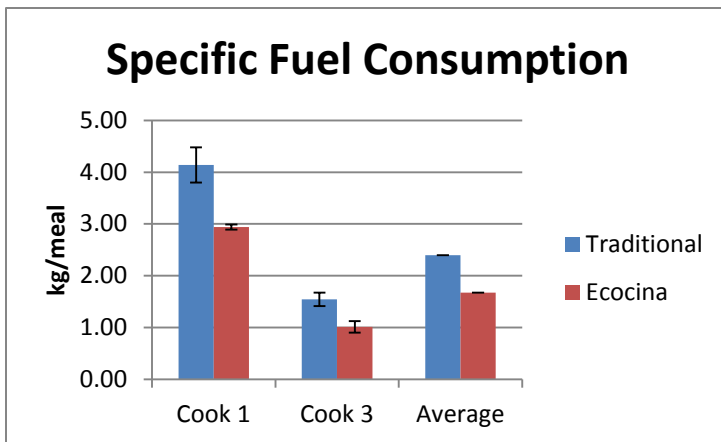
In Guatemala black beans are a staple food and it was determined that a CCT that did not evaluate the fuel use, cooking time, and emissions when cooking black beans would not be representative of in-field use. In the end it was decided that a meal of black beans and tortillas would be necessary. This presented a challenge as there would only be enough time to perform two cooking tasks per day and the allotted time for the training would not be enough to complete the full study. It was decided that Cook 1 would cook black beans on each stove while Cook 2 and Cook 3 would instead cook a meal of tortillas and a rice/vegetable dish. While this is a slight variation from the CCT protocol, as each cook is performing the same task on each stove the results for reductions will still be valid as well as showing if those reductions vary between cooks.

The trainees included Marco Tulio Buezo from EcoComal factory in Guatemala, Anibal Murcia from E'Copan factory in Honduras, Gustavo Peña from Inversiones Falcón factory in El Salvador, Eric Ramirez from Herreria Lupita factory in Mexico and Walter Meyer, a volunteer engineer from StoveTeam International. The trainees took turn leading each of the CCTs. By doing this as well as taking turn transferring the data from the collection sheet to the excel sheet, each of the trainees gained the skill to perform the complete test alone. By the end of the training the members of StoveTeam were performing all of the tasks of the CCT without assistance from ARC.

## Controlled Cooking Test

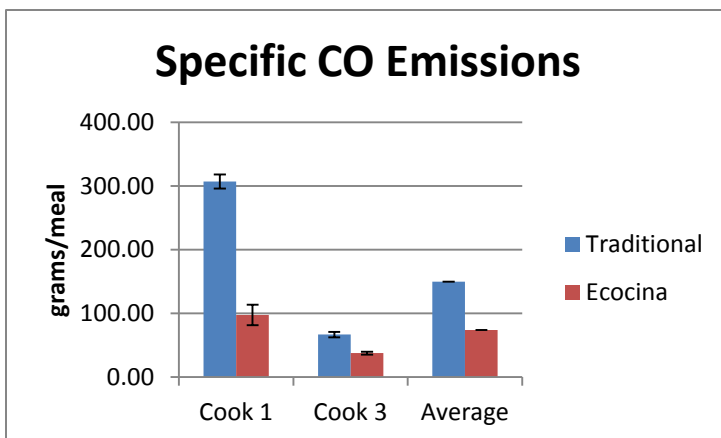
The purpose of the CCT was to make sure that the staff was trained on the protocol as well as to get significant results.

As noted above, it was asked that Cook 1 would cook black beans and Cooks 2 and 3 were asked to cook tortillas and a rice and vegetable dish. The charts and tables below show a similar reduction in fuel use and emissions for the two chosen tasks. Results for Cook 2 did not reach the required 95% statistical significance so were left out of the official reduction results.



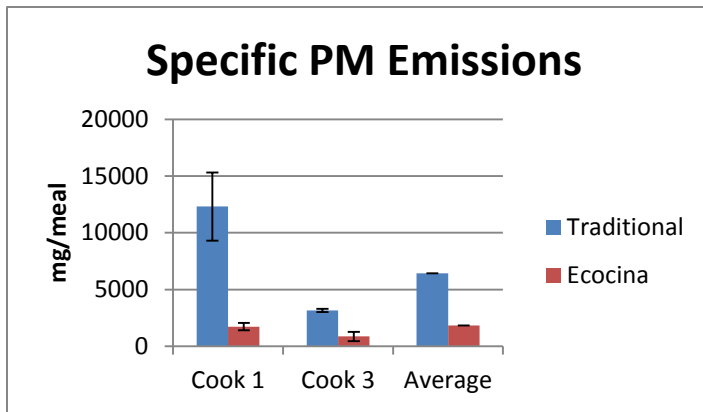
### Fuel Consumption:

There was an average fuel reduction of 31% from the traditional three stone fire to the Ecocina.



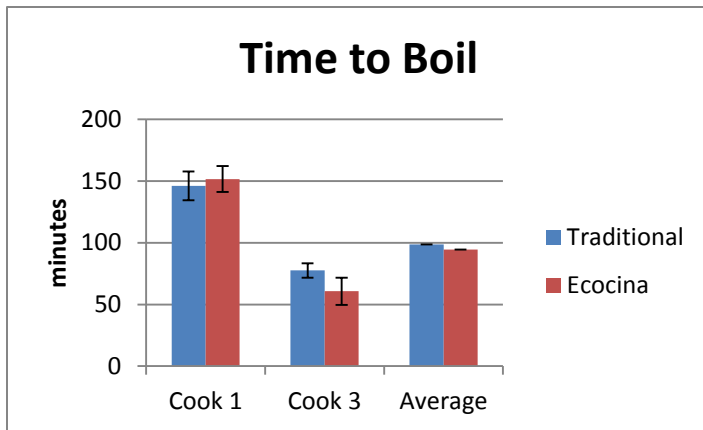
### Carbon Monoxide:

There was an average CO reduction of 64 % from the traditional three stone fire to the Ecocina.



### Particulate Matter:

There was an average PM reduction of 78% from the traditional three stone fire to the Ecocina.



### Time to Cook:

There was no significant difference in the time to cook between the two stoves

### Cook 1 CCT detailed results:

1. CCT results: Stove 1		units	Test 1	Test 2	Test 3	Mean	St Dev
Specific fuel consumption	g/meal		3.66	4.38	4.37	4	0
Specific CO production	g/meal		315.38	291.56	313.78	307	13
Specific PM Production	mg/meal		15,318	8,218	13,400	12,312	3,673
Total cooking time	min		162	134	142	146	14

2. CCT results: Stove 2		units	Test 1	Test 2	Test 3	Mean	St Dev
Specific fuel consumption	g/meal		2.89	2.99	2.94	3	0
Specific CO production	g/meal		81.57	113.72	97.65	98	16
Specific PM Production	mg/meal		1,397	2,049	1,723	1,723	326
Total cooking time	min		162	141	152	152	11

Comparison of Stove 1 and Stove 2		% difference	T-test	Sig @ 95% ?
Specific fuel consumption	g/meal	29%	4.98	YES
Specific CO production	g/meal	68%	17.36	YES
Specific PM Production	mg/meal	86%	4.97	YES
Total cooking time	min	-4%	-0.53	NO

### Cook 3 CCT detailed results:

<b>1. CCT results: Stove 1</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Mean</b>	<b>St Dev</b>
Specific fuel consumption	g/meal	1.40	1.58	1.65	2	0	
Specific CO production	g/meal	64.03	64.73	71.86	67	4	
Specific PM Production	mg/meal	3,322	3,098	3,070	3,163	138	
Total cooking time	min	73	76	84	78	6	
<b>2. CCT results: Stove 2</b>		<b>units</b>	<b>Test 1</b>	<b>Test 2</b>	<b>Test 3</b>	<b>Mean</b>	<b>St Dev</b>
Specific fuel consumption	g/meal	0.95	1.14	0.95	1	0	
Specific CO production	g/meal	38.76	35.27	39.29	38	2	
Specific PM Production	mg/meal	1,333	572	681	862	411	
Total cooking time	min	72	60	50	61	11	
<b>Comparison of Stove 1 and Stove 2</b>			<b>% difference</b>	<b>T-test</b>	<b>Sig @ 95% ?</b>		
Specific fuel consumption	g/meal		35%	5.42	YES		
Specific CO production	g/meal		44%	10.39	YES		
Specific PM Production	mg/meal		73%	9.19	YES		
Total cooking time	min		22%	2.35	NO		

### Discussion of results and recommendations:

A full CCT is normally one typical meal from the region cooked by three different cooks three times each on the two stoves under comparison. In Guatemala the challenge arose that one of the most common meals cooked was black beans which take so long to cook that it was not realistic to combine them with other dishes. It would not be accurate to choose only beans in the evaluation of the stoves. In past studies it was decided to conduct multiple CCT's for each of the common dishes. In this case it was decided that one of the cooks would cook black beans while the other two would cook a common accompaniment of rice and tortillas. Since both stoves would be tested in the same way it was decided that this variation in the protocol was acceptable.

Stove development and monitoring and evaluation of stove projects have the unfortunate history of too little focus being put on gathering scientifically valid results. The CCT protocol results page give feedback as to whether 95% significance is reached. If it is not reached then the course of action is to conduct more tests, to present results with that qualification or to leave those results out. In this case data was processed after the study had taken place so there is not the option at this time to conduct more tests with cook 2. It was chosen to present only those results reaching the desired statistical validity. Full data and results, statistically valid or not, are available for presentation outside of this report.