Partnership for Clean Indoor Air

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Connecting People's Capacities

The Controlled Cooking Test (CCT)

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Our Task for Monitoring and Evaluation

1 – To get cleaner burning and fuel reducing stoves to more people.

2 - To determine what will be the performance of every stove we have built for all of eternity without having to go and monitor the performance of every stove we have built for all of eternity…

Just that easy!!!!!

Rationale for the SPT

Demonstrate impact of ICS projects using methods that are…

- Standardized and repeatable
- Comparable within and across projects
- Statistically sound

…but still appropriate and flexible enough to adapt to local circumstances and constraints!

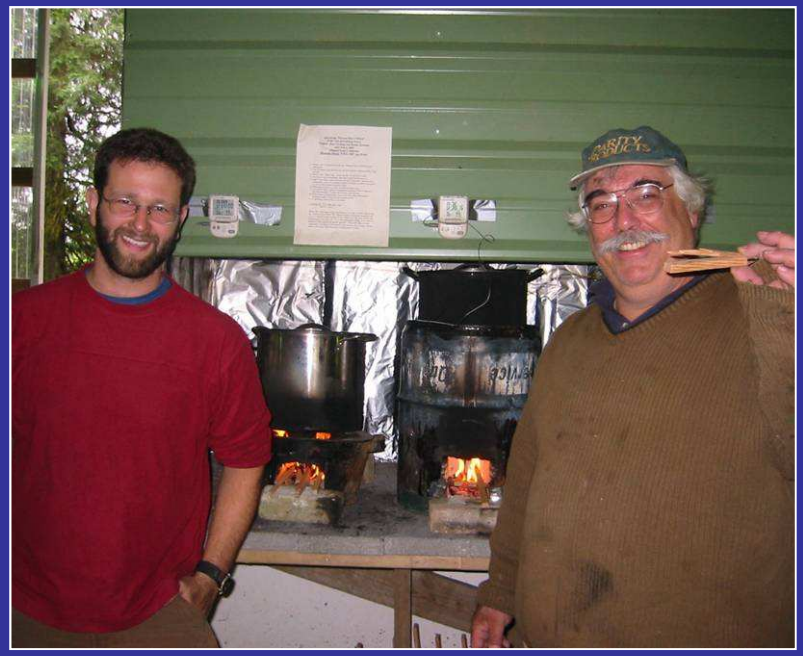
- Caveat: Monitoring is important but question of allocation of resources

And because everything…

Stove Performance Testing (SPT)

Past and present

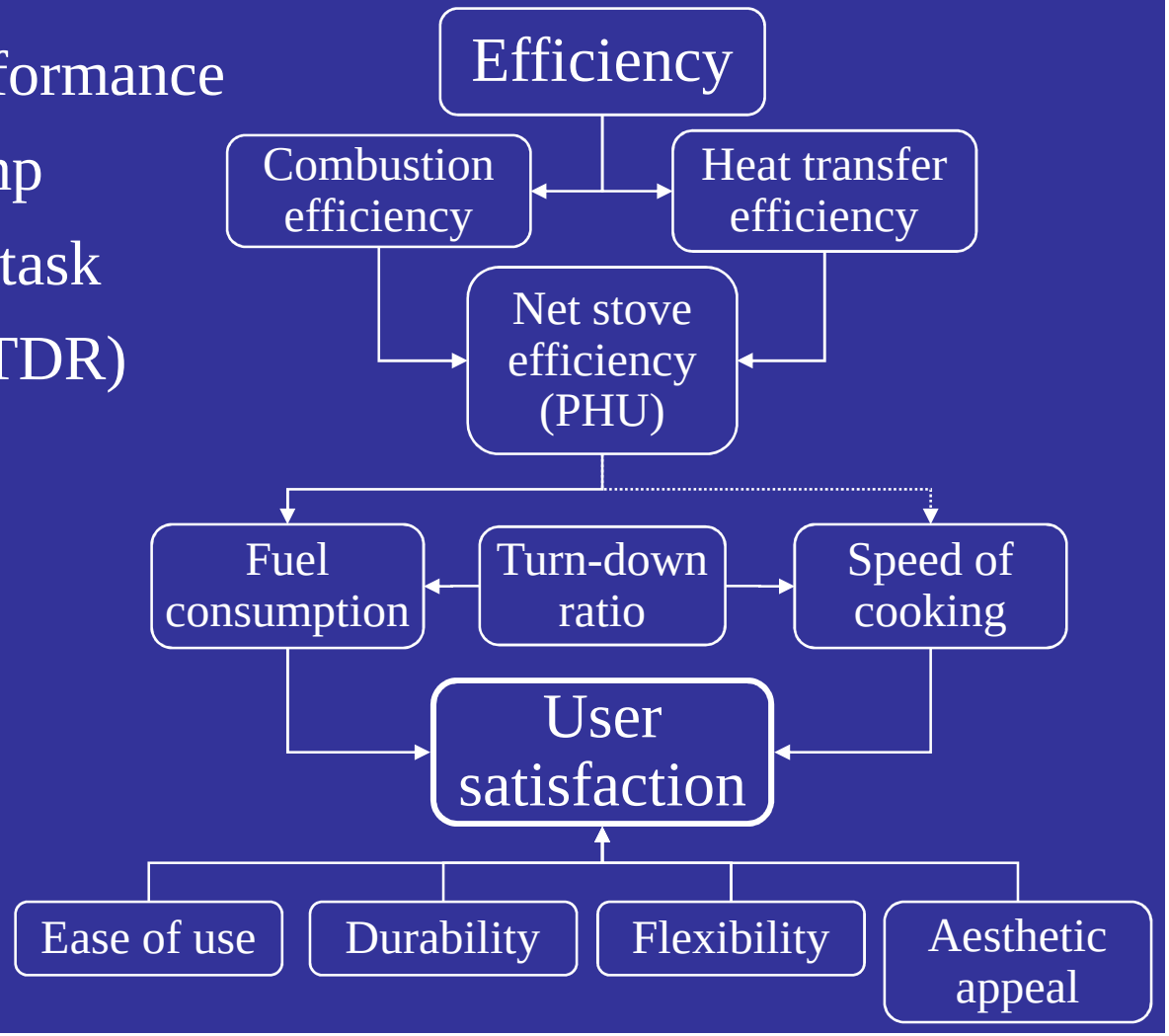
- In 1985 VITA developed a set of protocols for testing stove performance
- Functional, yet somewhat cumbersome and not generally used
- In 2003 Shell/EPA request UC Berkeley and Aprovecho to develop a new set of universally adopted SPT protocols



What is *Stove Performance*?

Measures of Stove Performance

1. Efficiency/exit temp
2. Fuel consumption/task
3. Turn-down ratio (TDR)
4. Speed of cooking
5. *User satisfaction*
6. Emissions



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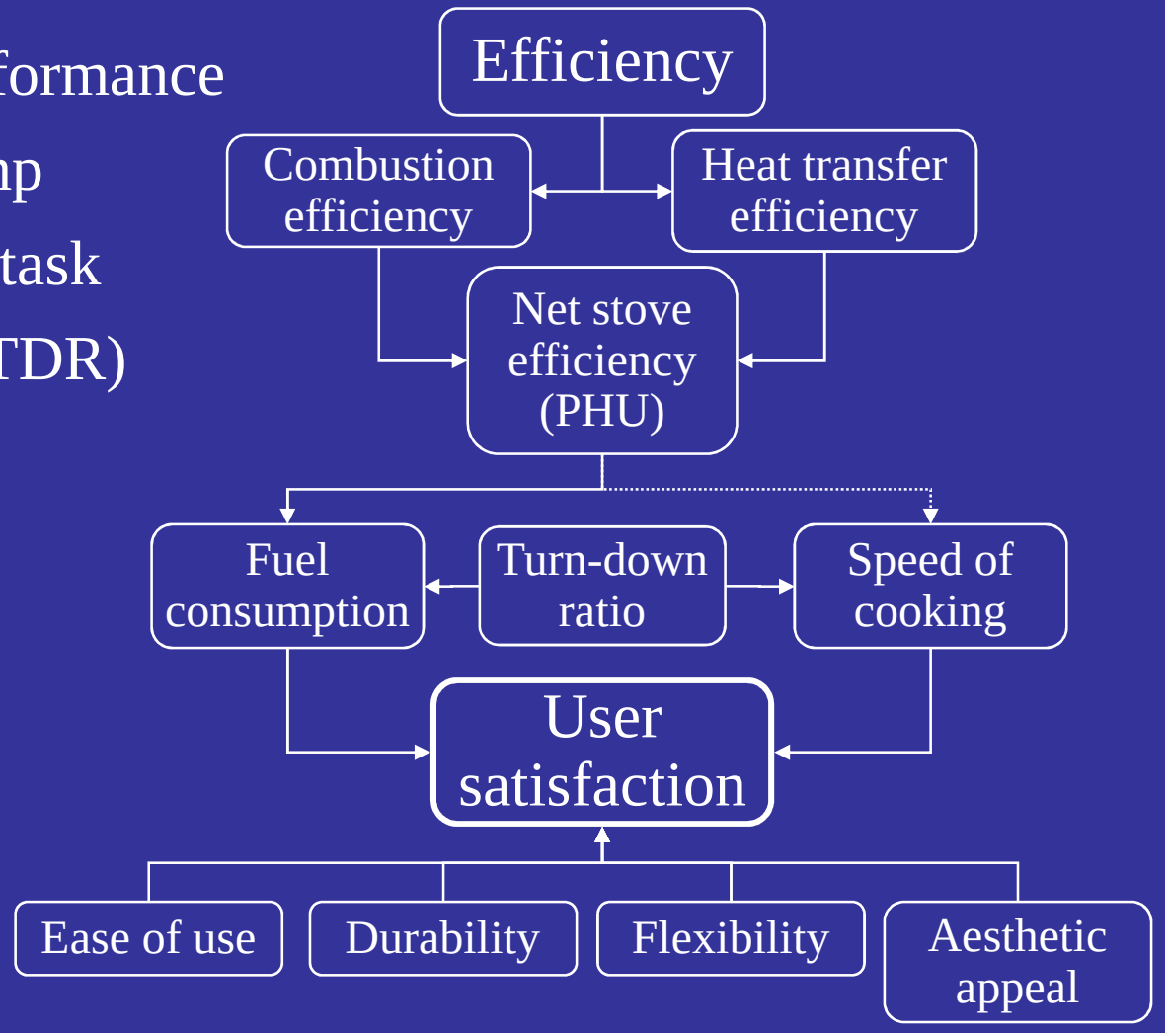


CCT Measures of performance

2. Specific Consumption- The amount of fuel needed to complete a particular task (example: boil a kilo of water, cook a kilo of food, or bake a kilo of bread)

For us this is the most useful number to make a guess as to which stove will most likely save fuel in real use

$$\text{Specific consumption} = \frac{Mw - 1.5Mc}{Wf}$$

CCT Measures of performance

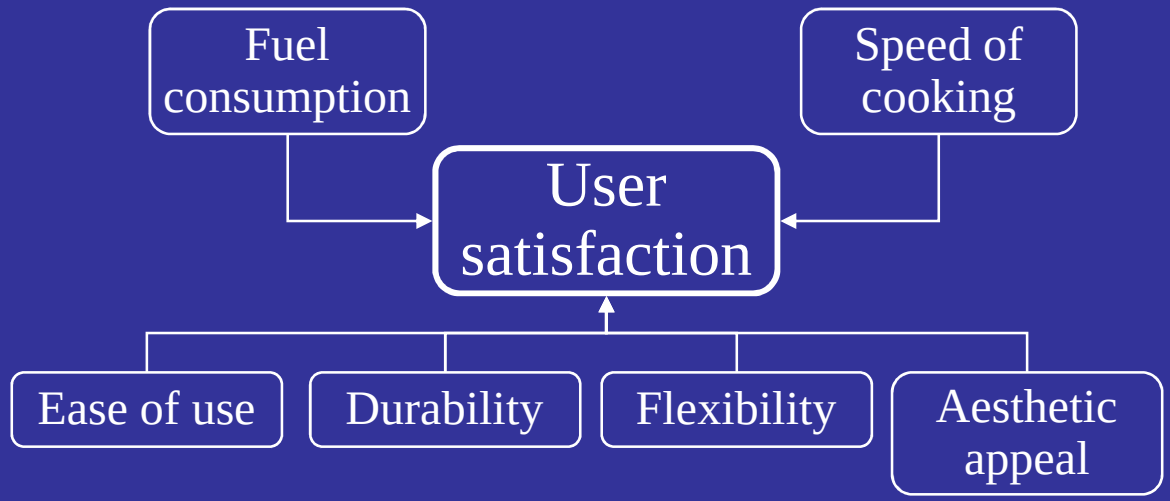
4. Speed of cooking

This is a measure more of user friendliness then fuel consumption

Can be either lab or field-base

CCT Measures of performance

5. Overall User satisfaction
   - Hard to measure, subjective, and dependent on many factors



CCT Measures of performance

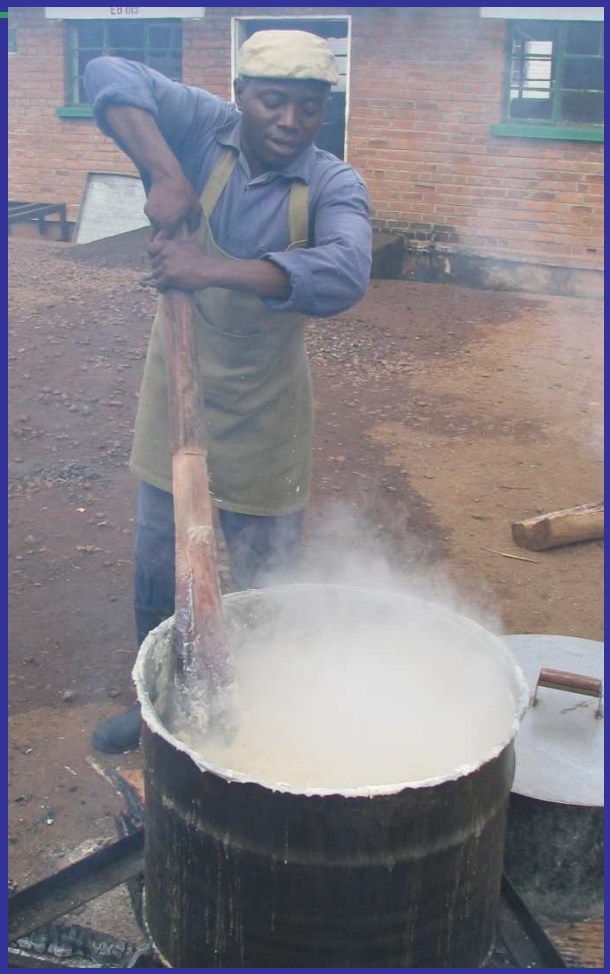
6. Emissions

Testing of emissions/exposure/dose is a much less exact science without proper equipment

With PEMS/IAP meter we hope to make this more accessible

Controlled Cooking Test **(CCT)**

- lab controlled test with added variables of an actual cook cooking real food
- Only can be used to compare two stoves from a particular project
- Compares fuel consumption (specific consumption), and speed of cooking
- Much better at predicting actual stove performance and fuel consumption in the field



Advantages to the CCT

- Controlled Variables:
  1. Food – A single meal in a standard quantity – eliminates variations for family size, visitors, holidays, etc.
  2. Room – Conducting tests with emissions collection or emissions in the same room -- eliminates the variation between kitchens.
  3. Cook - By requesting the same cook prepare the same meal on both the improved and traditional stove, the difference in the **stoves** alone can be better isolated

- Controlling these variables saves time and expense, while providing strong data with less scatter than a KPT.

- At the **end** of the test, the cooks can be asked what they thought of the stove.

Disadvantages to the CCT

- There is still tester intervention – cooks may not use the stove the exact way they would at home.
- Only one meal is investigated, while real-world use likely involves variable meals, tea, wash water, etc.

CCT Supplies: Cooks

- In choosing cooks, they should be committed and available to complete the full test series
- It is nice to let the cooks keep the food to share with family/village at the end of tests. This helps to ensure the food is cooked well, and that the cook feels compensated for her time.
- Perhaps the cooks should also be paid a reasonable rate for participating.
- The cooks should be asked to prepare meals, but not necessarily told that the stoves are being studied. The less biased she is, or trying to “do well” to please the tester, the better.

CCT Supplies: Fuel

- Fuel used for the test should be representative of the fuel most commonly used
- It is important that there be enough of the same fuel to complete the entire CCT series
- It is important that the fuel is all in the same condition of dryness

CCT Supplies: Food

- A common recipe should be chosen
  - "Doneness" of the meal should be easily identified
  - Should not take too long or too little time to prepare for ease of planning.
  - It helps to choose something that the cooks will appreciate taking home at the end of the day!
- The recipe ingredients, including any needed water, should be provided to the cook in pre-weighed bundles prior to beginning the cooking. She should use all of each ingredient
- The cook should use the pots (and lids) that she would normally use

CCT Procedure

- The cooks should have plenty of time (2+ weeks) to learn to use the improved stove to the level of expected local recipient of the stoves.
- It is important to clearly explain to the cooks in advance what will happen during the CCT:
  - She will be provided pre-weighed ingredients
  - She should cook the meal the same way every time
  - When the meal is finished cooking, she should tell the tester
  - The cooked food will be weighed (before draining) as soon as the meal is finished
- During the test, the cooks should not be told how to run the stove
- The cooks should not be asked questions about how they like the stove until all the tests are over. *We do not want to bias the cooks so that they change their behavior during the test.*

CCT Procedure

- During the test, the tester should make notes about the ease of use of the stove.
- The tester should be available nearby to immediately weigh the remaining food and fuel as soon as the meal is finished cooking.
- *****Weighing Charcoal*****
  - If the charcoal is “saved” or used for some other cooking, the charcoal should be weighed and credited back to the stove.
  - If the charcoal is simply let to burn out, it should not be weighed, since the fuel is wasted.

CCT Sample Size

- One CCT is considered to be:
  - one cook cooking the same meal
    - 3 times on the traditional stove
    - 3 times on the improved stove

      Therefore **1** CCT = **6** meals by one cook
- A CCT series should be done with at least 3 cooks completing a 6-test CCT, for a total of 18 meals.
- More cooks or additional meals can be used if statistical confidence* is not achieved.
  - *Statistical confidence means a COV of the %Improvement between cooks of less than 25%

CCT Data Collection

Controlled Cooking Test

Local Boiling Temp		Test number		Stove
Actual Temp				
Dimensions of wood		Wood Type		
Weight Pot 1				
Weight Pot 2		Moisture Content		
Weight Pot 3		Notes:		
Weight Pot 4				
Weight total incredients				
Weight total incredients				

	Inicial	Final
Weight total incredients		
Time	0 min	
Weight Wood		
Weight Pot 1 plus cooked food		
Weight Pot 2 plus cooked food		
Weight Pot 3 plus cooked food		
Weight Pot 4 plus cooked food		
Weight of Charcoal plus container		

CCT Data Analysis

See Data Calculation Sheet

CCT Emissions

- Emissions during the CCT can be measured in two ways:
  - Perform the test under PEMS which provides total mass emissions
  - Perform all tests in the same room with a stable level of ventilation while measuring IAP.

CCT Field Study in India

- Aprovecho worked to develop rocket stoves for Shell Foundation in Southern India. To determine the field performance of the stoves, an extensive series of CCTs was conducted in December 2007.
- Three stoves models: single-pot, double-pot, and double-pot with chimney. Performance was compared to traditional stoves, three-stone fire, and kerosene as used in the region.
- The outcome was extensive data from two emission measurement settings (PEMS and IAP monitor), for a total of 120 meals analyzed.

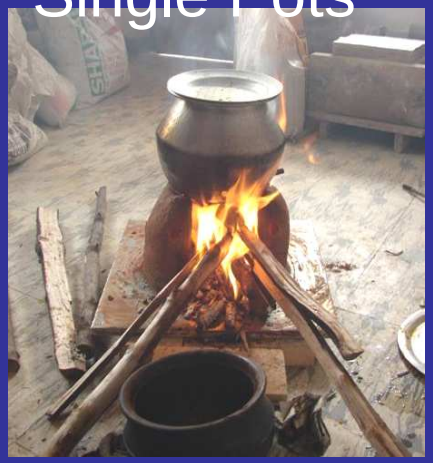
Cooks	**Single Pot**	**Double Pot**	**Chimney**	**Kerosene**	**Three-Stone Fire**
Cook A Cook B Cook C	3 Meals Each Improved, 3 Meals Each Traditional			3 Meals, Various Cooks	3 Meals, Various Cooks
Cook D Cook E Cook F		3 Meals Each Improved, 3 Meals Each Traditional			
Cook G Cook H Cook I			3 Meals Each Improved, 3 Meals Each Traditional		

CCT - Stoves

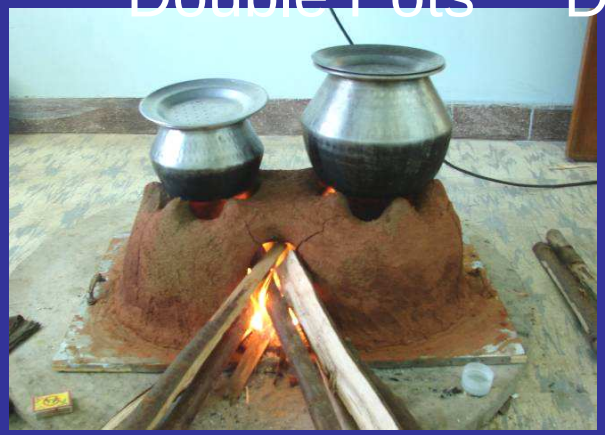
Improved

Traditional

Single Pots



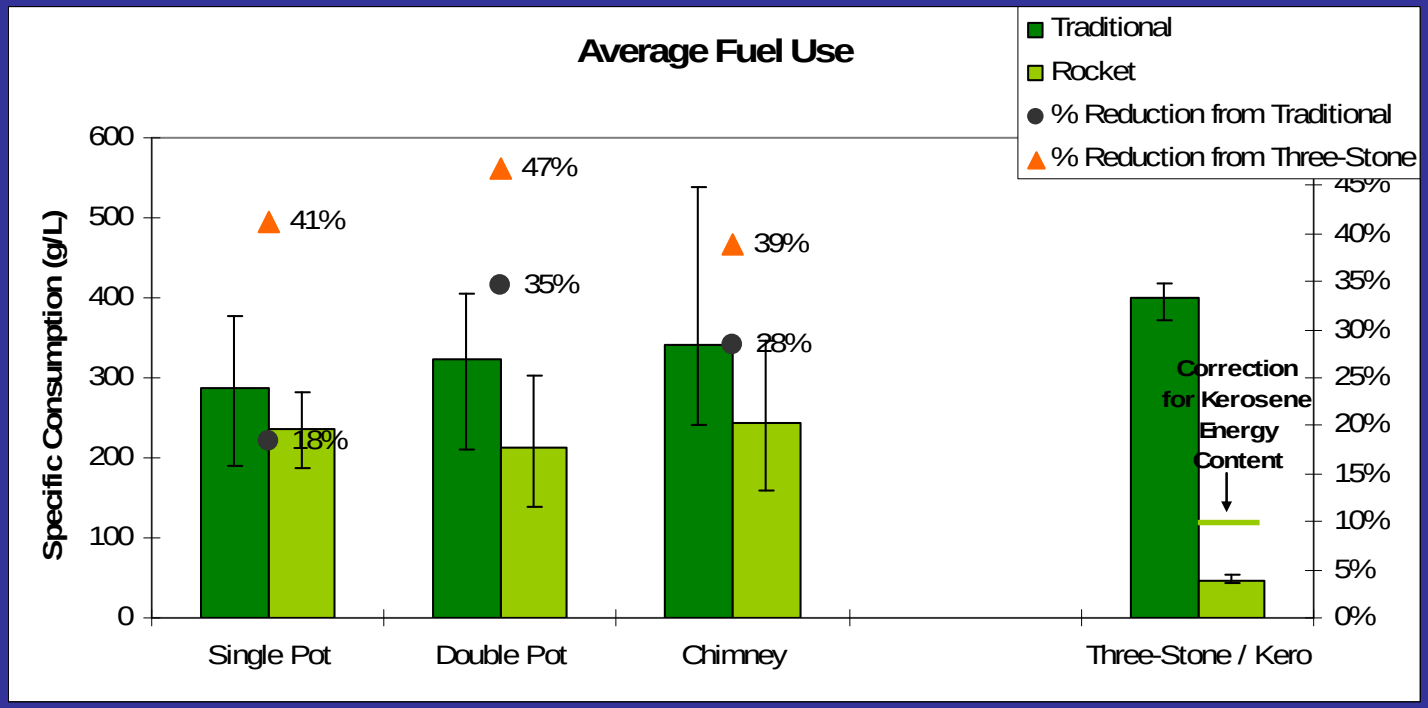
Double Pots



Double Pot with Chimney

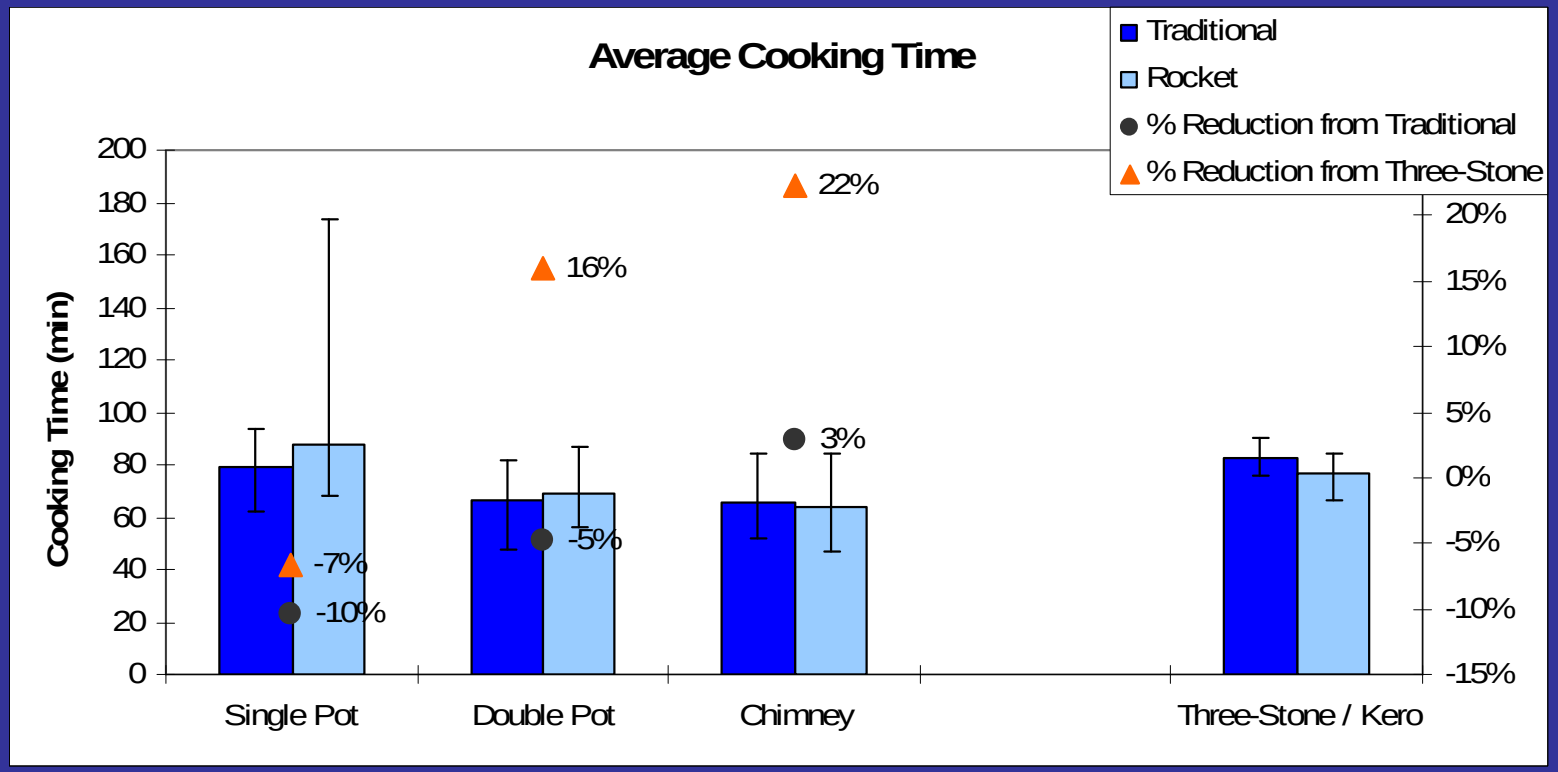
The nine cooks were located in nearby villages and given improved stoves 3 weeks prior to test. No training or instruction was provided before or during the tests. They were paid 50 Rupees per meal and given the large quantities of food to take home to share with their village.

CCT – Fuel



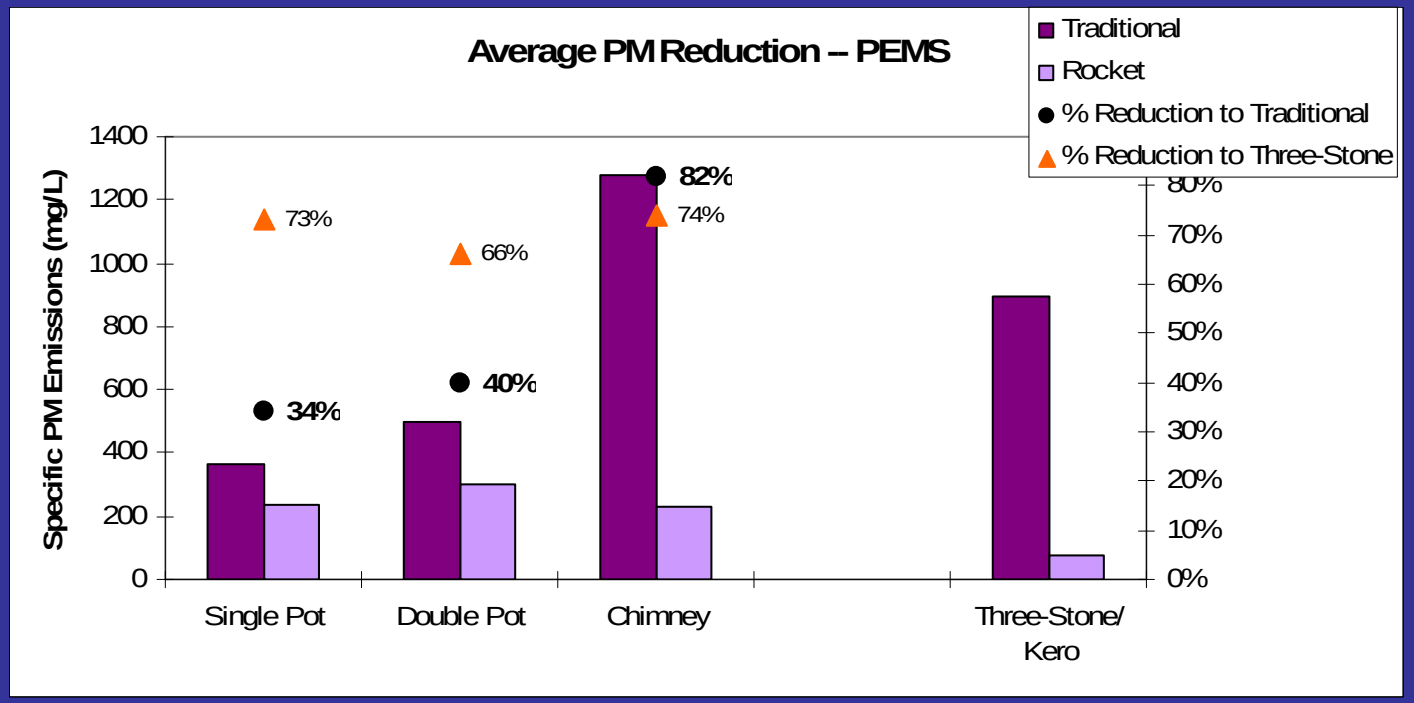
The rocket stoves saved between 18 and 35% of the fuel compared to the traditional stoves. When compared to the three-stone fire, the rockets saved about 40%.

CCT – Time



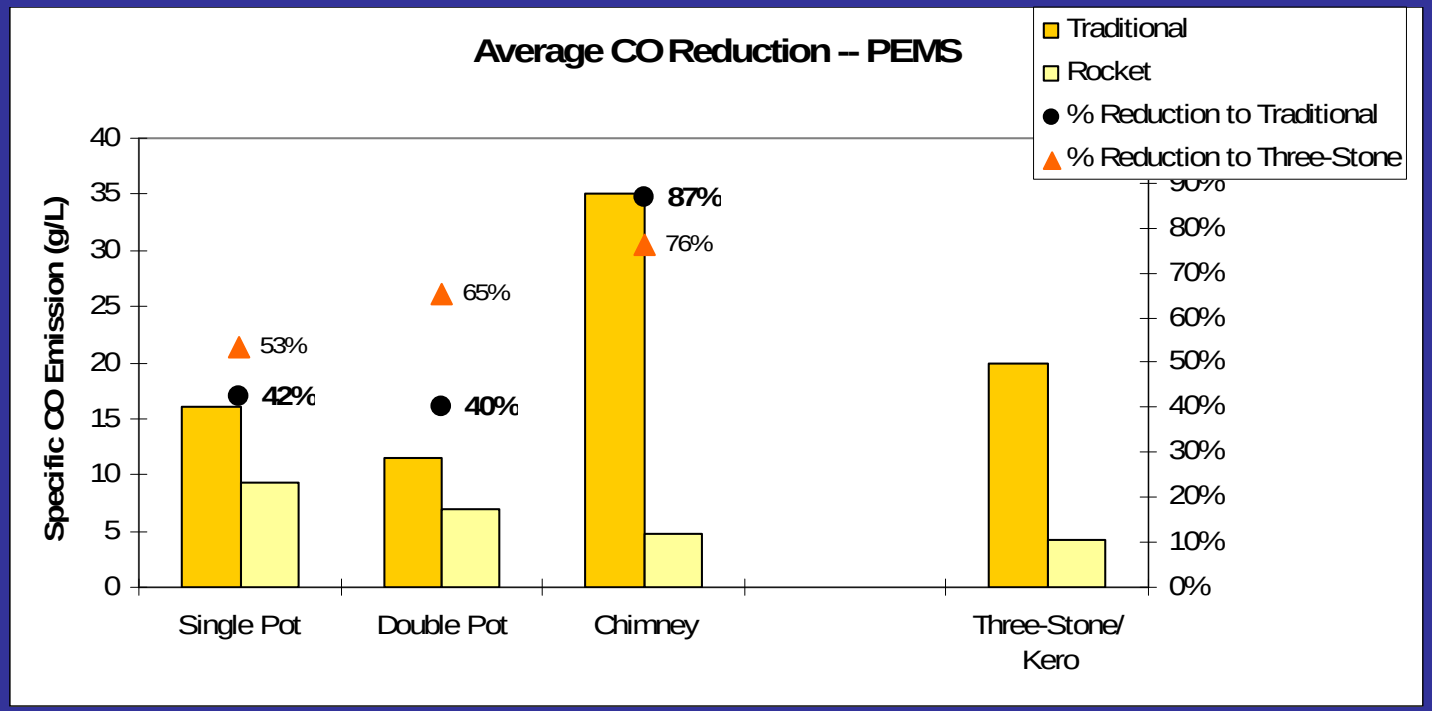
Single pot rocket stoves took about the same time to cook the meal as their traditional. Double-pots saved about 20% of the time

CCT – Total Emissions



The non-chimney stoves reduced total PM by 34%-40% compared to traditional, and about 70% compared to the three-stone. The rocket chimney stove released 82% less PM out the chimney than cement chimney stove with poor draft.

CCT – Total Emissions



The rockets reduced CO by about 40% vs. traditional and 53-60% compared to the three-stone. Similar to the PM results, insufficient draft resulted in high levels of CO from the traditional chimney stove.

Where to find the detailed tests

http://www.aprovecho.org/lab/pubs/testing