Controlled Cooking Test

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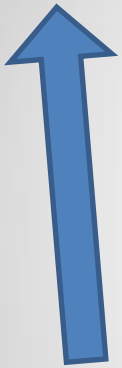
VERC Training

Ryan Thompson

Lab Technician

Aprovecho Research Center

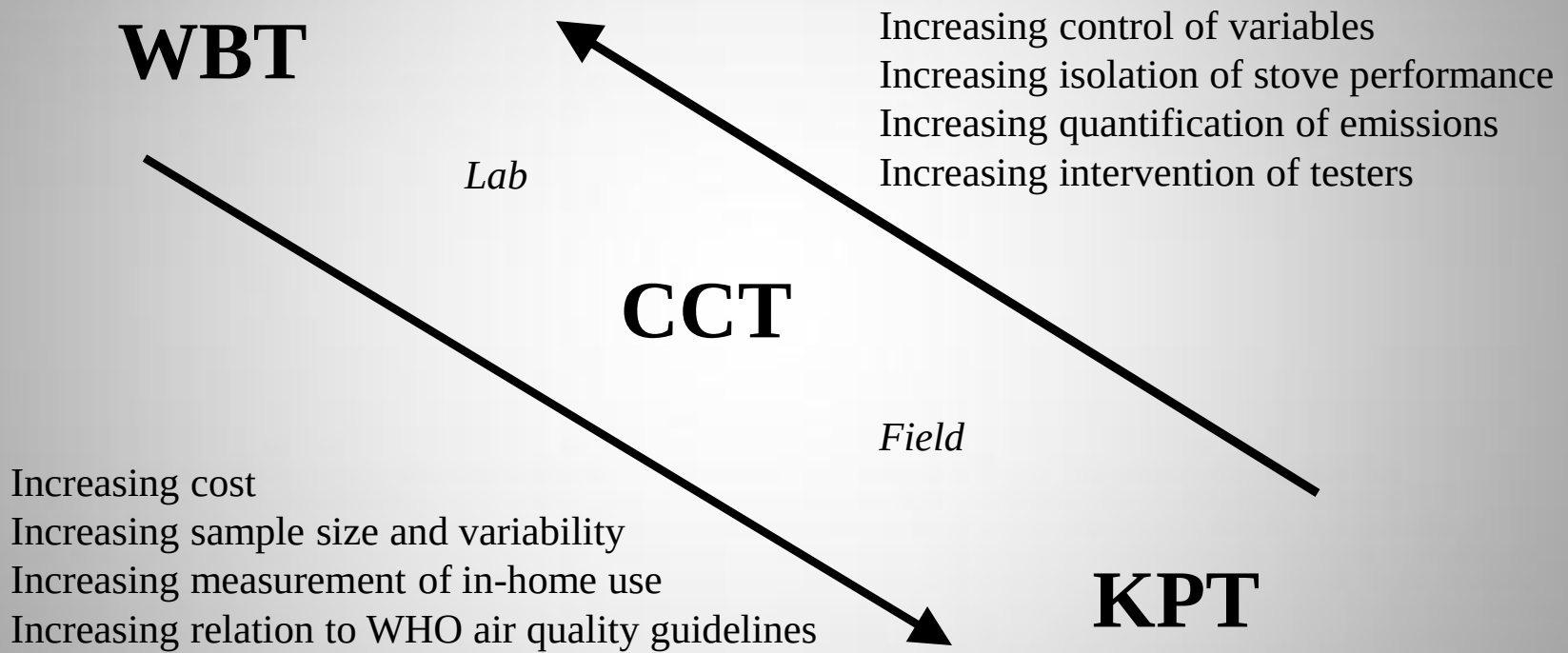
Controlled Cooking Test



Same cook
Same fuel
Same meal
for each stove

Real cook
Real food

Stove Testing Continuum



CCT Purpose

Compare the performance of 2 (or more) stoves for a real cooking task

Especially useful for comparing traditional vs. improved stove

Determine the % improvement for:

Fuel use
Cooking time
Emissions

CCT Advantages

- Realistic – real meal, real cook
- Some controlled variables
  - Fair comparison
  - Small, affordable sample size
- Stove design tool – useful design info by observation and interview of cook

CCT Disadvantages

- Not completely realistic
  - Testing with only one meal does not represent the real range of performance requirements.

    Ex: boil, boil, fry, steam, warm, etc.
  - Testing with only a few cooks does not represent all cooks.
  - Cooks may use the stove differently than they would in their own kitchen because of different environment.

CCT Performance Metrics

1. Specific Fuel Consumption
2. Cooking Time
3. Emissions

Specific Emissions or IAP Concentrations

CCT Specific Fuel Consumption

$$SC = \frac{grams\ of\ fuel\ consumed}{kg\ of\ food\ cooked}$$

Fuel consumed is corrected for moisture content and char remaining (f_d)

$$f_d = \left(f_f - f_i\right) * \left(1 - (1.12 * m)\right) - 1.5 * \Delta c_c$$

$$f_d = equivalent\ dry\ wood\ consumed$$

CCT Cooking Time

$$= t_f - t_i$$

Total cooking time recorded with timer

CCT Specific Emissions

Collect total emissions with PEMS

Then calculate

$$\mathrm{SE} = \frac{grams\ emission}{kg\ food\ cooked}$$

$$SE_{CO} = \frac{grams\ CO}{kg\ food\ cooked} \qquad SE_{CO_2} = \frac{grams\ CO_2}{kg\ food\ cooked} \qquad SE_{PM} = \frac{grams\ PM}{kg\ food\ cooked}$$

CCT Emissions - Indoor Air Pollution

Place IAP Meter in the kitchen or on the cook to measure the emissions concentrations

Average CO concentration (ppm)

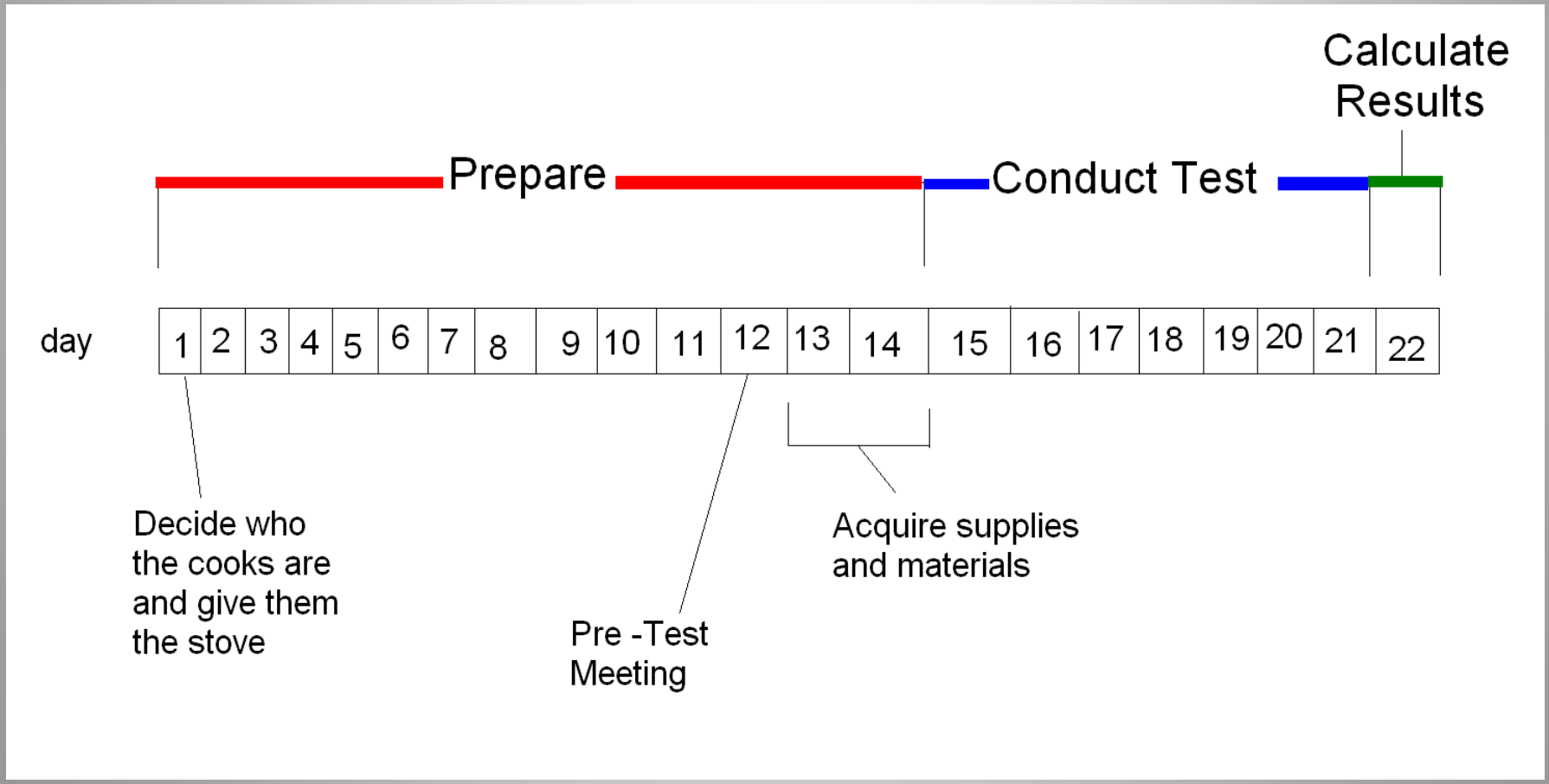
“parts per million”

Average PM concentration (ug/m3)

“micrograms per cubic meter”

CCT Procedure

Hypothetical Schedule



CCT Pre–Test Meeting

Cooks and testers meet to determine the meal that will be cooked

1. Create list of common meals
2. Choose a meal that is:
   - Representative of a typical family meal
   - Meets the time and resource constraints of the project

CCT Pre–Test Meeting

3. Record detailed instructions and quantities of food on the Cooking Task Sheet
   - Be **objective**, not subjective.

Objective:

"The beans are done when the skin peels off"

Subjective:

"The beans are done when they taste right"

The Standardized Cooking Task

Use this space to describe the standardized cooking process that forms the basis of this test. Describe each step with enough detail so that an experienced cook from the area where the test is performed could follow them easily. If more space is needed, extend the description below the space provided.

Ingredient	Name	Amount (g)
1	Rice	1000
2	Tomato	700
3	onion	500
4	ginger	100
5	garlic	100
6	salt	40
7	water	2500
8	oil	50
9		
10		
11		
12		
13		
14		
15		
16		
17		
18		
19		
20		

Step	Directions
1	Dice tomatoes, onion, ginger, garlic.
2	Fry onions, garlic, ginger, in the pot with the oil until browned
3	Add diced tomato, salt, water, rice and put lid on pot
4	Meal is done when rice is soft
5	
6	
7	
8	
9	
10	

CCT Pre–Test Meeting

4. Estimate the amount of fuel needed to cook the meal (kg/meal)

5. Decide if the char remaining should be counted as unburned fuel (ask the cooks if they use the char)

CCT Supplies

1. Fuel
   - One big batch for the entire test series
   - Common fuel, uniform moisture content
   - Amount:

$$2.5\ \frac{kg}{meal} * 3\frac{meals}{stove} * 2\text{stoves} * 2 = 30\ \text{kg}$$

Info from cook

Fudge Factor

Fuel for 1 CCT (6 tests)

CCT Supplies

2. Food
3. Pots
   - local pot or dedicated stove pot
   - lids are acceptable
4. Other cookware to prepare food
   - Knives, cutting board, dishes, etc.
5. Scale: 6 kg max, 1 gram resolution
6. Moisture meter or oven

CCT Supplies

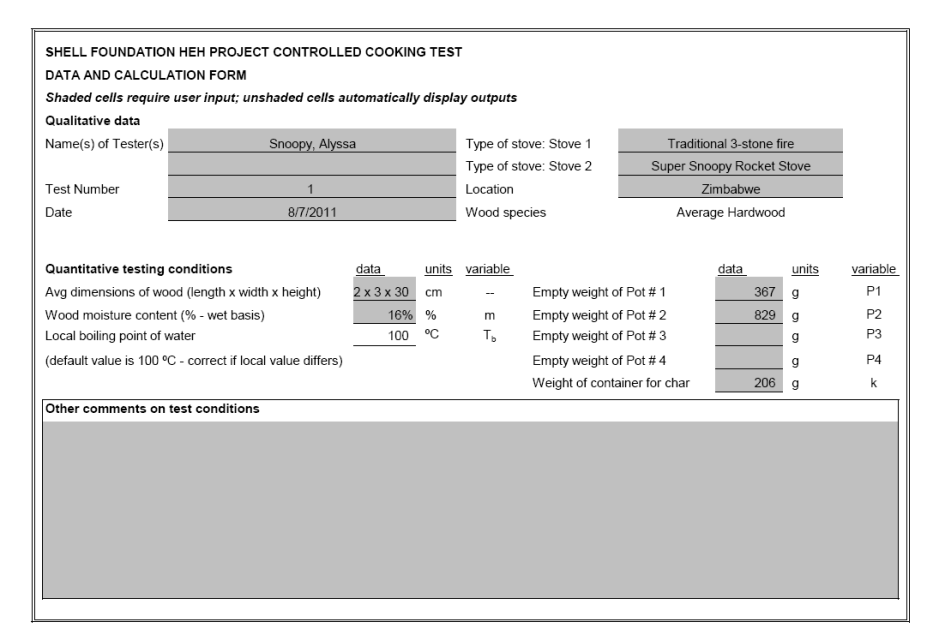
7. Timer
8. Thermometer
9. Heat resistant gloves

If weighing char:

10. Heat pad for scale
11. Char tray
12. Char scooper

CCT Conducting the Test

1. Fill out Data and Calculation Form



SHELL FOUNDATION HEH PROJECT CONTROLLED COOKING TEST

DATA AND CALCULATION FORM

Shaded cells require user input; unshaded cells automatically display outputs

Qualitative data

Name(s) of Tester(s)	Snoopy, Alyssa	Type of stove: Stove 1	Traditional 3-stone fire
		Type of stove: Stove 2	Super Snoopy Rocket Stove
Test Number	1	Location	Zimbabwe
Date	8/7/2011	Wood species	Average Hardwood

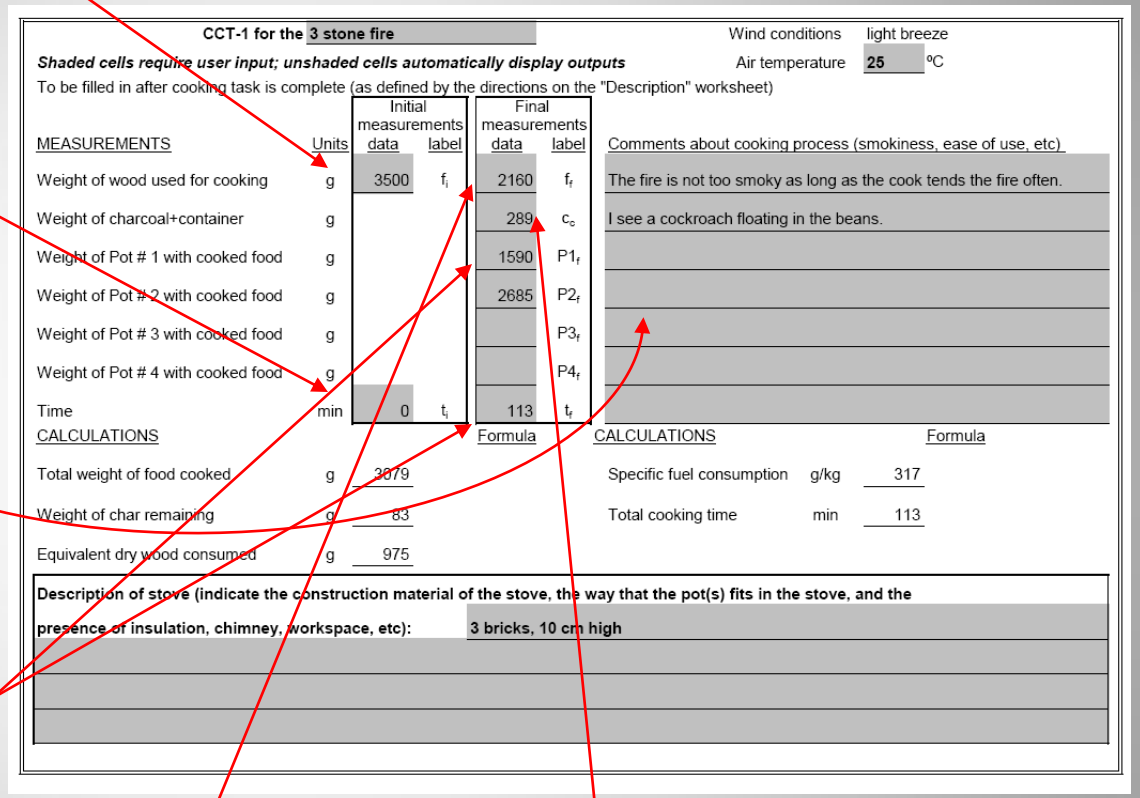
Quantitative testing conditions	data	units	variable		data	units	variable
Avg dimensions of wood (length x width x height)	2 x 3 x 30	cm	--	Empty weight of Pot # 1	367	g	P1
Wood moisture content (% - wet basis)	16%	%	m	Empty weight of Pot # 2	829	g	P2
Local boiling point of water	100	ºC	T_b	Empty weight of Pot # 3		g	P3
(default value is 100 ºC - correct if local value differs)				Empty weight of Pot # 4		g	P4
				Weight of container for char	206	g	k

Other comments on test conditions

2. Prepare food – chop, weigh, etc.

CCT Conducting the Test

3. Weigh and record starting bundle of fuel (more than enough)
4. Start timer when cooking begins
5. During the test record observations, notes, and comments about the cook
6. When food is cooked record end time and weigh food in pots



CCT-1 for the 3 stone fire

Wind conditions: light breeze

Air temperature: 25 °C

Shaded cells require user input; unshaded cells automatically display outputs

To be filled in after cooking task is complete (as defined by the directions on the "Description" worksheet)

MEASUREMENTS	Units	Initial measurements data	Initial measurements label	Final measurements data	Final measurements label
Weight of wood used for cooking	g	3500	f_i	2160	f_f
Weight of charcoal+container	g			289	c_c
Weight of Pot # 1 with cooked food	g			1590	$P1_f$
Weight of Pot # 2 with cooked food	g			2685	$P2_f$
Weight of Pot # 3 with cooked food	g				$P3_f$
Weight of Pot # 4 with cooked food	g				$P4_f$
Time	min	0	t_i	113	t_f

Comments about cooking process (smokiness, ease of use, etc)

The fire is not too smoky as long as the cook tends the fire often.

I see a cockroach floating in the beans.

CALCULATIONS			Formula
Total weight of food cooked	g	3079	
Weight of char remaining	g	83	
Equivalent dry wood consumed	g	975	

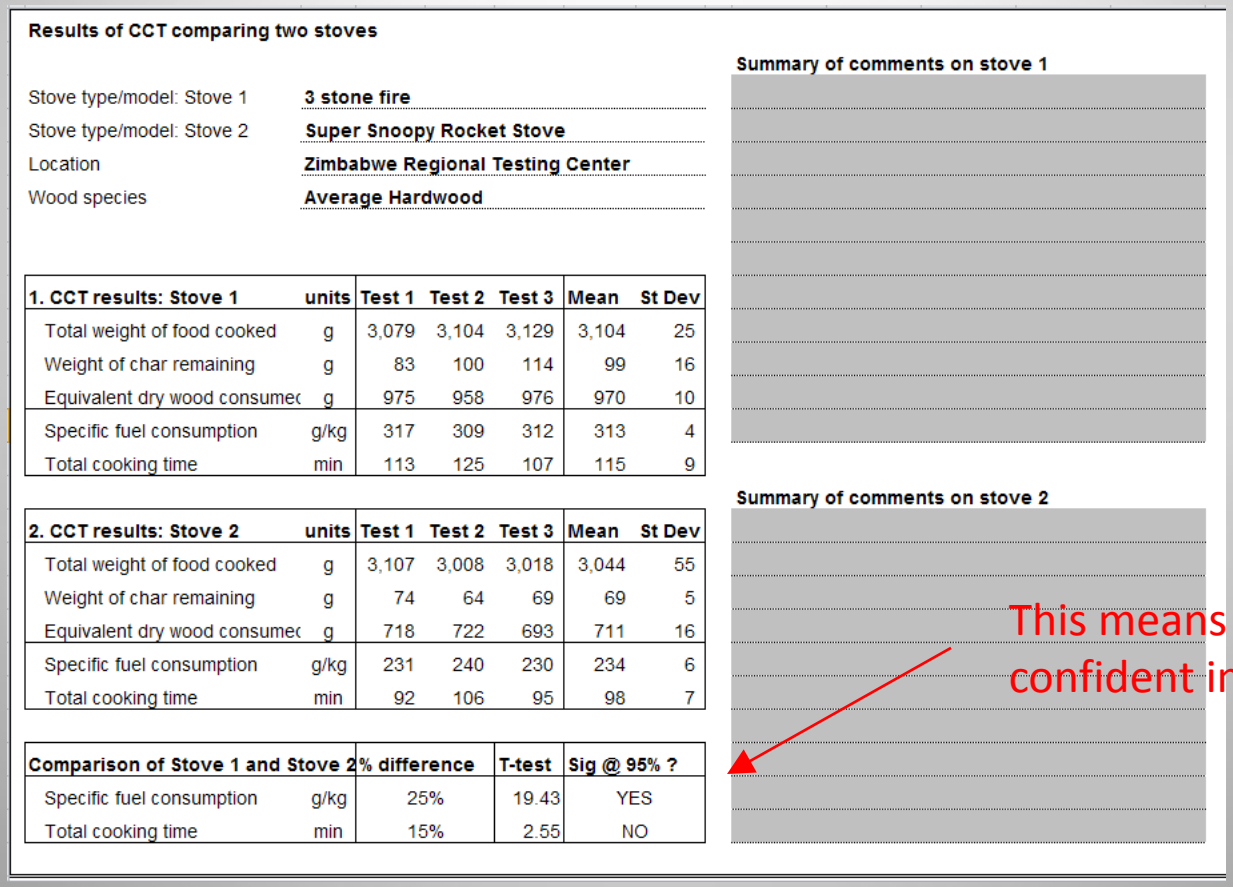
CALCULATIONS			Formula
Specific fuel consumption	g/kg	317	
Total cooking time	min	113	

Description of stove (indicate the construction material of the stove, the way that the pot(s) fits in the stove, and the presence of insulation, chimney, workspace, etc): 3 bricks, 10 cm high

7. Weigh and record unburned wood (break off char)
8. Weigh and record char (if appropriate)

CCT Calculate Results

- Enter test data into the Excel spreadsheet then go to results page



Results of CCT comparing two stoves

Stove type/model: Stove 1	**3 stone fire**
Stove type/model: Stove 2	**Super Snoopy Rocket Stove**
Location	**Zimbabwe Regional Testing Center**
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	3,079	3,104	3,129	3,104	25
Weight of char remaining	g	83	100	114	99	16
Equivalent dry wood consumed	g	975	958	976	970	10
Specific fuel consumption	g/kg	317	309	312	313	4
Total cooking time	min	113	125	107	115	9

2. CCT results: Stove 2	units	Test 1	Test 2	Test 3	Mean	St Dev
Total weight of food cooked	g	3,107	3,008	3,018	3,044	55
Weight of char remaining	g	74	64	69	69	5
Equivalent dry wood consumed	g	718	722	693	711	16
Specific fuel consumption	g/kg	231	240	230	234	6
Total cooking time	min	92	106	95	98	7

Comparison of Stove 1 and Stove 2		% difference	T-test	Sig @ 95% ?
Specific fuel consumption	g/kg	25%	19.43	YES
Total cooking time	min	15%	2.55	NO

Summary of comments on stove 1

Summary of comments on stove 2

This means you are 95% confident in the result

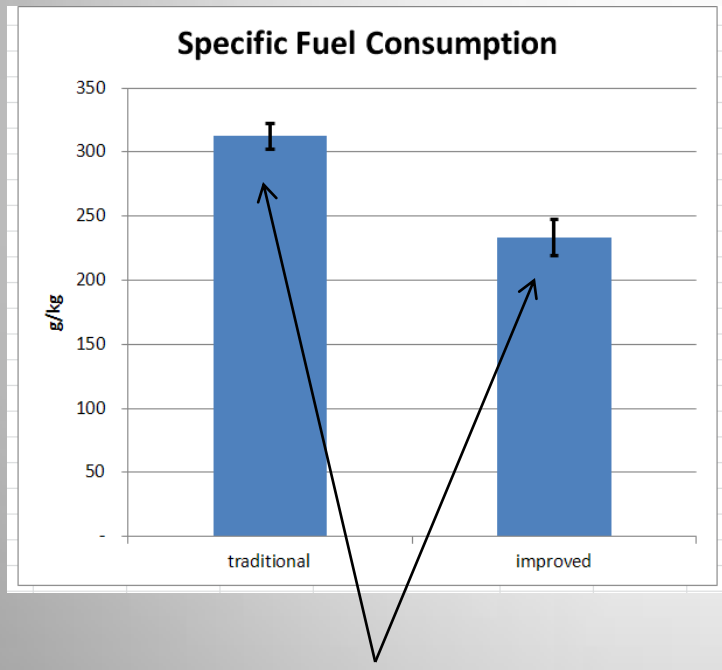
CCT Statistics: The T-Test

The T-Test answers the question:

Are the two stoves significantly different?

Yes

No

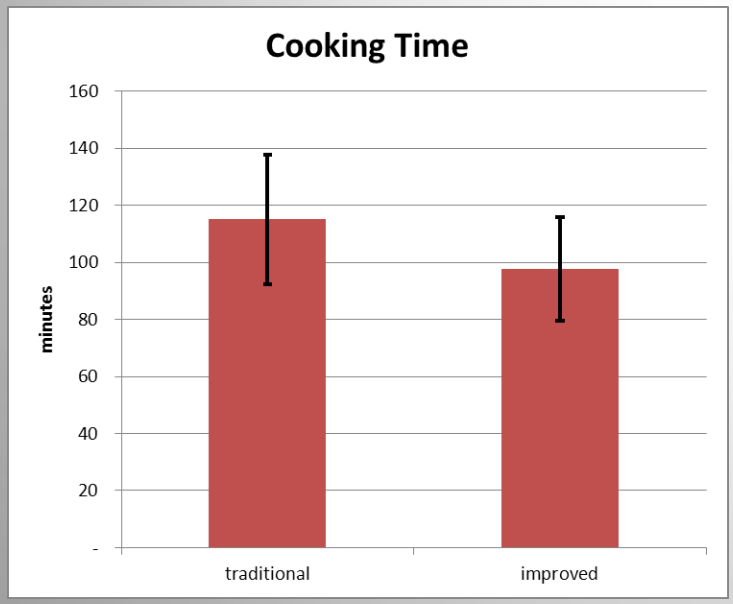


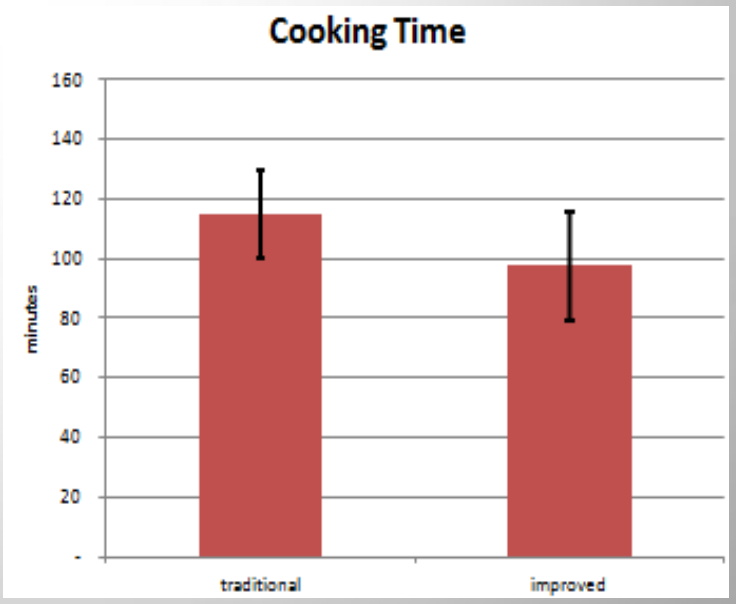
The confidence intervals are a measure of the standard deviation

CCT Sample Size

Do more tests with the same cook and stove combination in order to show that 2 stoves are significantly different

If sample size ↑, confidence intervals ↓, and the 2 stoves become significantly different





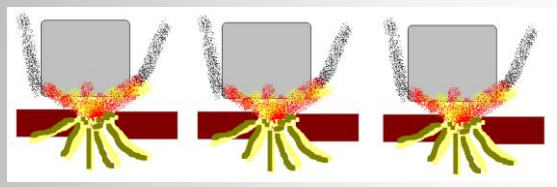
3 tests not sig different @ 95% confidence level

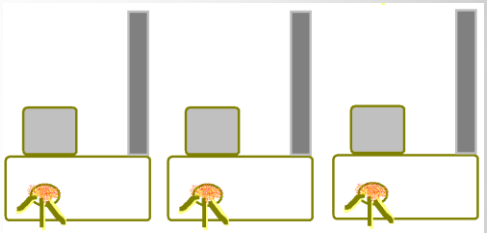
N tests sig diff @95% confidence level

CCT Sample Size

1 CCT means:

1 cook





= 6 tests

3 tests on each stove

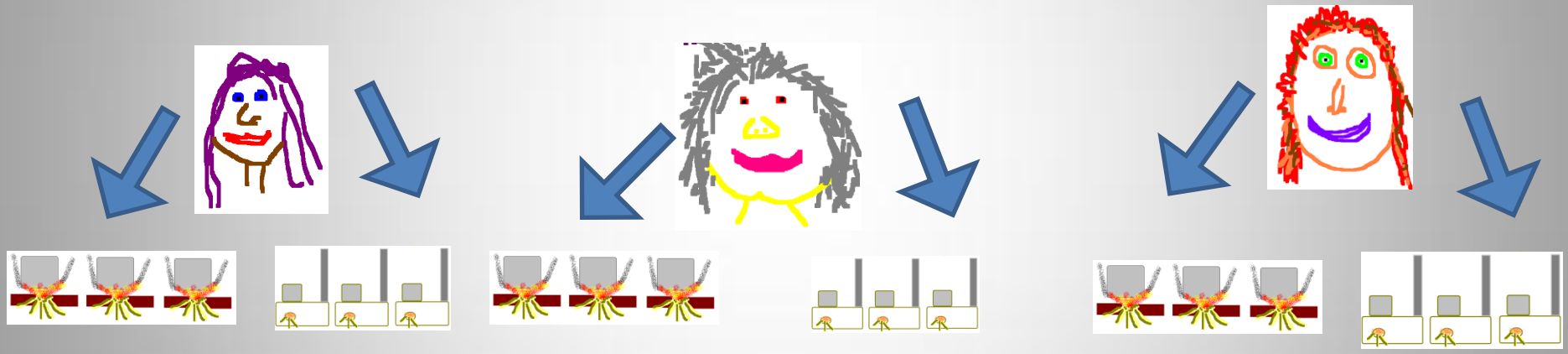
Increase the sample size by:

Adding more cooks
Adding more stoves

CCT Sample Size

Add more cooks

1 full CCT series = 3 cooks



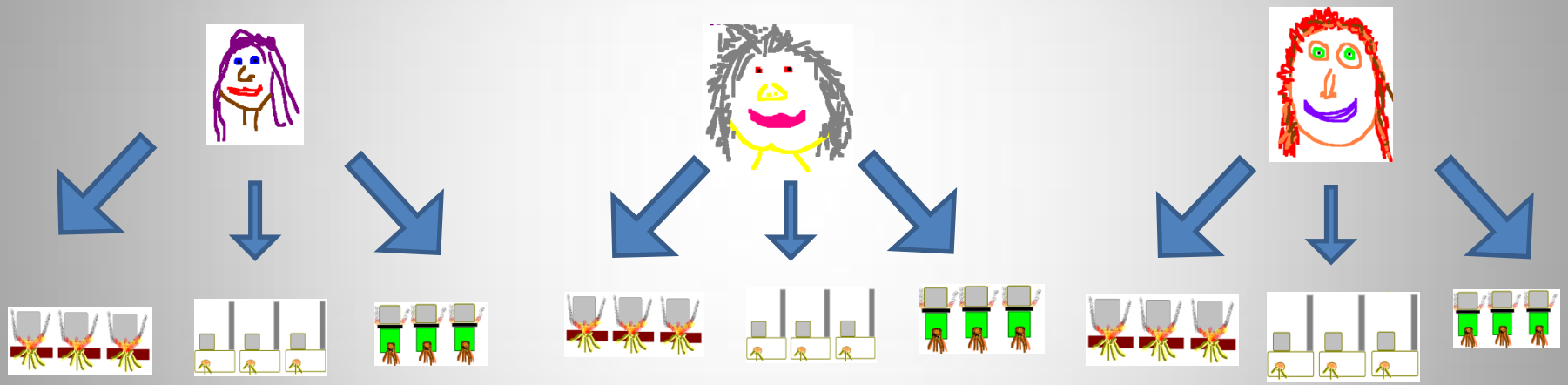
= 18 tests

It’s a better representation of a real population

CCT Sample Size

Add more stoves

1 CCT = 9 tests



1 full CCT series = 27 tests

CCT Documentation

- www.aprovecho.org/lab/pubs/testing