Partnership for Clean Indoor Air

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The Kitchen Performance Test

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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

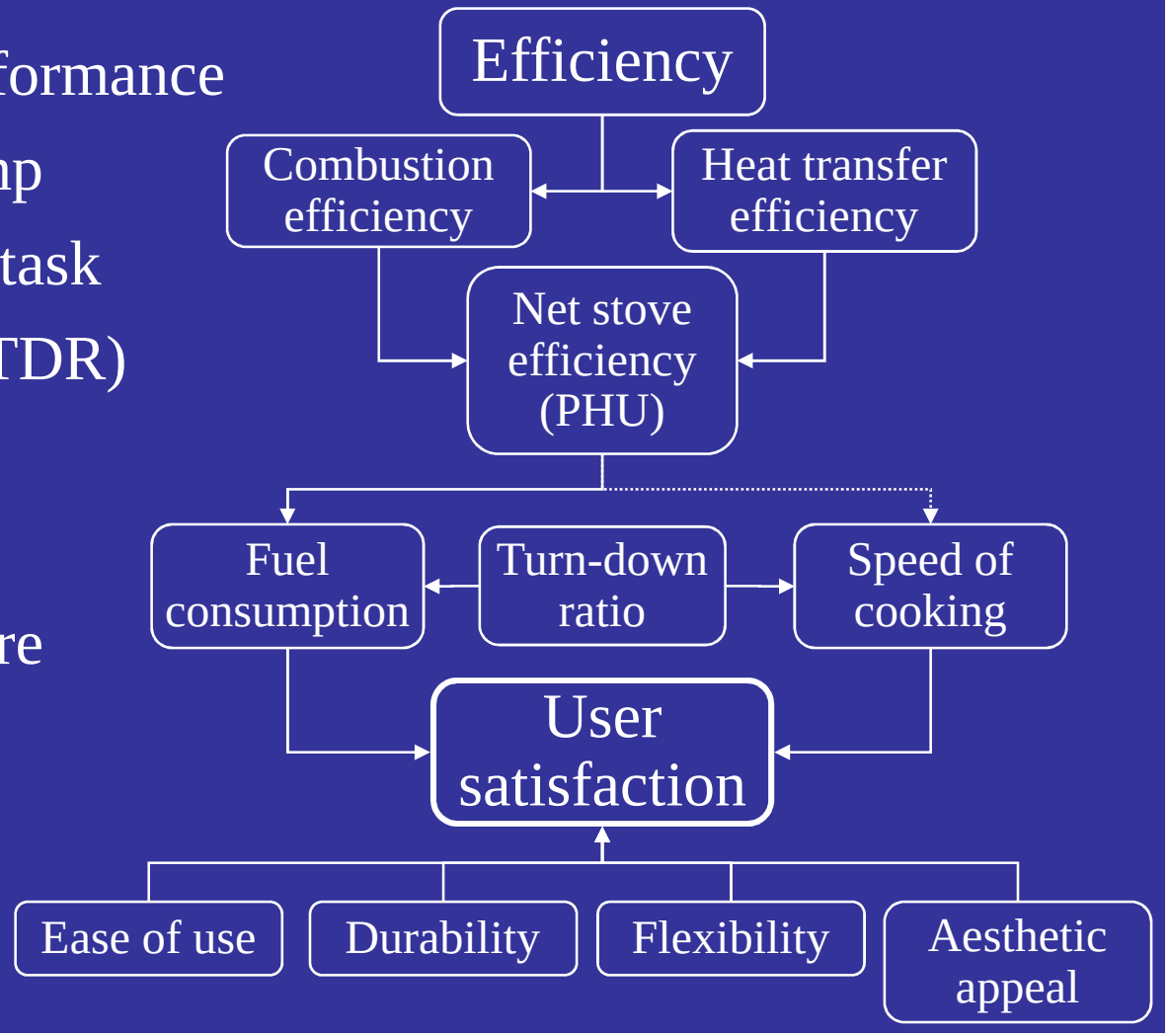
…but still appropriate and flexible enough to adapt to local circumstances and constraints!

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

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/Exposure



KPT Measures of Performance

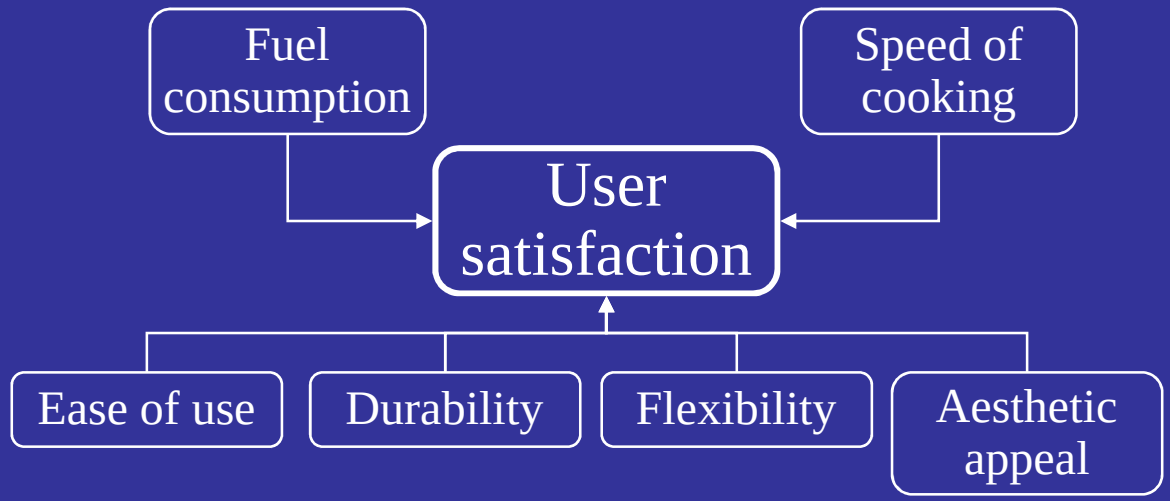
2. Specific Consumption- The amount of fuel needed to complete a particular task (example: boil a kilo of water, cook a kilo of food, or bake a kilo of bread)

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

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

KPT Measures of Performance

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



KPT Measures of Performance

6. Exposure

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

Water Boiling Test (WBT) Review

1 - Based largely on VITA (1985) and Baldwin (1986) with small modifications

- **Limits Variables**
- **Transferable between various projects**

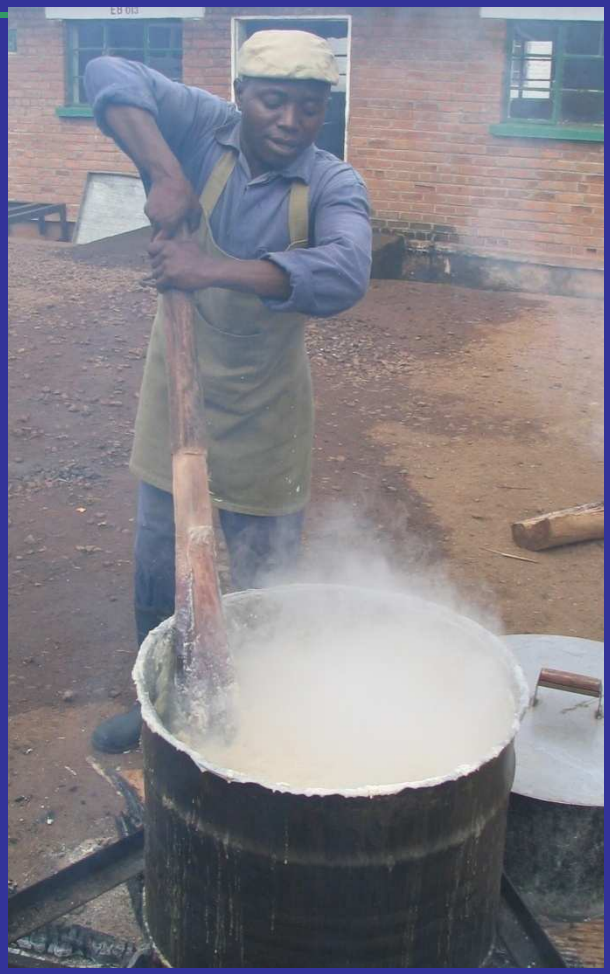
Lab-based test provides 4 of the 6 indicators of SP:

1. PHU
2. Specific Consumption
3. TDR
4. Time to boil
5. Emissions

But it is unsure if the results from WBT correspond to actual data from users (the CCT and KPT).

Controlled Cooking Test **(CCT)** Review

- 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,user satisfaction, and possibly emissions
- Much better at predicting actual stove performance and fuel consumption in the field



Kitchen Performance Test **KPT**

More complex than WBT and CCT:

- –Both qualitative survey and quantitative measurements
- –Takes stove testers into peoples households
- –Sampling procedure and study design are critical
- –Variability in “real-world” setting increases the number of samples needed to make results statistically valid
- –Gives daily wood consumption and gauges user satisfaction

KPT Purpose

- When we introduce a stove we are changing the future
- Future 1 – fuel use and exposure with traditional stoves
- Future 2 – fuel use and exposure with introduced stoves
- KPT is showing ACTUAL fuel use and exposure difference in households

KPT Advantages

- Fuel use and IAP levels are studies with essentially no intervention by the testers, thus show data close to the reality.
- A large sample gives a good view of what is really happening in homes.
- Conducting a survey along with the KPT can give other valuable information.

KPT Disadvantage

- Lots of confounding variables: holidays, visitors, use of other stoves, ventilation, fuel supply, etc.
- Requires a lot of preparation, time and leg-work in the villages.
- May be an inconvenience to the families – lots may drop out of the testing

When to do the KPT

- After stoves have been disseminated and users have adapted to them.
- Do not conduct the KPT until the stove has done well in the WBT and CCT, because stoves should not be disseminated unless they have done well in the first two tests.

KPT Supplies

- Scale for weighing weekly fuel supply
- Surveys
- IAP Monitoring Equipment
- Random selection of households willing to participate – prepare for drop-outs!
- FUEL SUPPLIED?
  - If yes, then family might use more wood
  - If not, then family might gather wood daily, making it more difficult to keep track.

KPT Procedure

- Survey

The Kitchen Performance Test, Version 1.5
August 20, 2004

Size of community (group of communities)	Number of households to be surveyed initially
Small (less than 300 households)	At least 30
Medium (300-1000)	~10%
Large (more than 1000 households)	100

12. What kind of stove(s) are used? What is the age and frequency of use of each stove?	Stove/fuel	Age of stove (yrs)	Frequency of use (times per day, week, or month)
	a)		
	b)		
	c)		
13. Whose job is it to obtain cooking fuel?	For each Stove/fuel from question 12, list the family members' gender and age as in question 7 above: a)		
	b) c)		
14. Where is cooking fuel obtained and roughly how far is the source of fuel from the household (record distance or time needed to walk to source)?	Give answers for each Stove/fuel given in question 12		
	Location a) b) c)	Distance from household a) b) c)	
15. How much is consumed and how much does the family	Give answers for each Stove/fuel listed in the response to question 12		

KPT Procedure

- Decide on Paired Sample or Cross-Sectional Sample:
  - 1.) PAIRED -- By doing fuel use measurements of the traditional stove with a family and then doing measurements as the SAME family useing the improved stove. This is a *longitudinal* or *panel* study.
  - 2.) CROSS-SECTIONAL -- Alternatively, testing can be done by comparing fuel use in two groups of families , with one group using the traditional stove and the other group using the improved stove. This is a *case-control* study, where the *control* group is a group of families that still use the old type of stove.

KPT Procedure

- Decide on Paired Sample or Cross-Sectional Sample:
  - PAIRED -- Testing is done in two stages. Requires more resources, more attention to changes in variables that come with different seasons etc.
  - 2.) CROSS-SECTIONAL – Testing done all at same time. Because of large variable of different families may result in larger sample sizes

KPT Emissions

- Emissions during the KPT can be measured in two ways:
  - IAP measurement in the kitchen
    - Meter placed in the kitchen, IAP recorded for as many days as possible
  - Exposure measurement of the cook
    - If the IAP meter can be placed on the cook, her exact exposure can be measured, which is what we are really looking to learn
    - “Human subjects” protocol should be considered
  - Must consider test duration (more days is better) based on capability of meter

KPT IAP Meter Placement

- Placement of the meter in the home has a very large effect on the results
  - Generally recommend 1.3 m over, 1.3 m up from stove (breathing level of typical woman)
  - Keep away from drafts, windows

KPT Procedure

- KPT consists of simply conducting regular measurements of fuel used for a number of days:
  - Weigh the difference in fuel supply each day
    - Must count and keep separate any additional fuel gathered each day
  - Check with family how many people ate that day in case of holiday, feeding workers, etc.
    - Can normalize fuel use per equivalent adult:

Gender and age	Fraction of standard adult
Child: 0-14 years	0.5
Female: over 14 years	0.8
Male: 15-59 years	1.0
Male: over 59 years	0.8

  - IAP monitoring Can be added

KPT Daily Data Form: **Family name/HH code:**

Shaded cells require user input - unshaded cells automatically display outputs (see note on fuel moisture)

Day 0

Initial stock of wood in inventory area ____ kg *(Measure and enter the total amount of wood that the family has at the start of the testing*

Day 1

Fuel consumed between day 0 and day 1

Fuel moisture (wet basis)*

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(keep apart from previous day's fuel and add after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Day 2

Fuel consumed between day 0 and day 1

Fuel moisture (wet basis)*

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(kept apart from previous day's weighed fuel - add to stock after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Day 3

Fuel consumed between day 2 and day 3

Fuel moisture (wet basis)*

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(kept apart from previous day's weighed fuel - add to stock after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Results - mass of fuel	Day 1	Day 2	Day 3	Avg	SD
No. of adult equivalents					
Wet wood used (kg)					
Wet wood per cap (kg/cap)					
Dry wood (kg)					
Dry wood per cap (kg/person)					

Results - energy consumption	Day 1	Day 2	Day 3	Avg	SD
Energy used (MJ)					
Energy per cap (MJ/cap)					

*** Fuel moisture**

If you are using the Delmhorst J-2000 moisture analyzer (the recommended instrument for measuring fuel moisture in these field tests) you will be measuring fuel moisture on a **dry basis**. You can use the averaging function on the meter to or enter data in the "Fuel Mois-ture" worksheet (immeditely followng this worksheet). That work-sheet will calculate the average moisture content (both dry and wet basis). The wet-basis will be output automatically to this work-sheet. If you are using an alternate method to calculate fuel moisture, ignore the "Fuel Moisture" work-sheet and enter the fuel moisture values (**wet-basis**) directly into this work-sheet.

KPT Daily Data Form: **Family name/HH code:**

Shaded cells require user input - unshaded cells automatically display outputs (see note on fuel moisture)

Day 0

Initial stock of crop residues or dung in inventory area ____ kg

(Measure and enter the total amount of fuel that the family has at the start of the testing period)

Day 1

Fuel consumed between day 0 and day 1

Fuel moisture (wet basis)* 0%

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(keep apart from previous day's fuel and add after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Day 2

Fuel consumed between day 0 and day 1

Fuel moisture (wet basis)* 0%

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(kept apart from previous day's weighed fuel - add to stock after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Day 3

Fuel consumed between day 2 and day 3

Fuel moisture (wet basis)* 0%

Fuel in stock ***(excluding new additions not weighed during previous visit)*** ____ kg

Fuel collected during past 24 hrs ***(kept apart from previous day's weighed fuel - add to stock after weighing)*** ____ kg

Fuel consumed in the past 24 hrs ____ kg

Results - mass of fuel	Day 1	Day 2	Day 3	Avg	SD
No. of adult equivalents					
Wet fuel used (kg)					
Wet fuel per cap (kg/cap)					
Dry fuel (kg)					
Dry fuel per cap (kg/person)					

Results - energy consumption	Day 1	Day 2	Day 3	Avg	SD
Energy used (MJ)					
Energy per cap (MJ/cap)					

*** Fuel moisture**

The Delmhorst J-2000 moisture analyzer is not designed to measure the moisture content of non-woody biomass. You should use an alternate technique described in the accompanying document and enter in the "non-woody fuel moisture worksheet"

KPT Daily Data Form: **Family name/HH code:**

Shaded cells require user input - unshaded cells automatically display outputs (see note on fuel moisture)

Gender and age	Child: 0-14	Female: over 1	Male: 15-59	Male: over 59
Adult equivalent	0.5	0.8	1.0	0.8

Day 1

People present for meals during the last 24 hour period

Children: 0-14	
Females: > 14	
Males: 15 - 59	
Males: > 59	
Total Adult Equivalent	

Day 2

People present for meals during the last 24 hour period

Children: 0-14	
Females: > 14	
Males: 15 - 59	
Males: > 59	
Total Adult Equivalent	

Day 3

People present for meals during the last 24 hour period

Children: 0-14	
Females: > 14	
Males: 15 - 59	
Males: > 59	
Total Adult Equivalent	

Shell Foundation HEH Project Kitchen Performance Test: Data and Calculation Form

Shaded cells require user input; unshaded cells automatically display outputs

Name(s) of Enumerator(s)		GPS coordinates	
		Type of stove	
Family name/HH code		Start date of KPT	
Administative division		Time family is to be visited	
Region/province		Is fuel provided (Yes/No)	

Schedule of KPT

Day 0: Initial briefing of famliy, defining wood inventory area, and weighing of initial stock of wood.

Days 1 and 2: Visit family at roughly the same time, weigh fuel remaining in stockpile and weigh any wood added on that day.

Day 3: Final weighing and debriefing of family. If possible, tell them the outcome of the test and present them with appropriate compensation.

Describe the location of the household (list distinguishing features like water sources, trees, and other details of the landscape)...

	Daily fuel use (kg)			Fuel use per capita (kg/person)		
	Average	SD	95% CI	Average	SD	95% CI
Wood						
Other biomass						
Coal or charcoal						
Kerosene						
LPG						

	Daily energy use (MJ)			Energy use per capita (MJ/person)		
	Average	SD	95% CI	Average	SD	95% CI
Wood						
Other biomass						
Coal or charcoal						
Kerosene						
LPG						
Total						

Statistical anaylysis of traditional and Improved Stove

	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
Average Per Capita Fuel Consumption TCS (Kg)	5.5	7.5	3.6	4					
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18
No. of adult equivelent people TCS household	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18
CV from KPT TCS household	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
	5	30	28	23					
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18

	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
Average Per Capita Fuel Consumption ICS (Kg)	4.4	4.6	1.9	4.3					
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18
No. of adult equivelent people ICS household	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18
CV from KPT ICS household	House 1	House 2	House 3	House 4	House 5	House 6	House 7	House 8	House 9
	27	23	11	54					
	House 10	House 11	House 12	House 13	House 14	House 15	House 16	House 17	House 18

Detectable difference in means between TCS and ICS	0.262136	Pooled CV of Measurements	25.125

KPT Sample Size

SAMPLE SIZE REQUIRED FOR THE PAIRED-SAMPLE TEST METHOD

	Pooled CV of measurements												
Detectable difference in means	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
10%	8	31	71	126	196	283	385	502	636	785	950	1130	1326
20%	2	8	18	31	49	71	96	126	159	196	237	283	332
30%	1	3	8	14	22	31	43	56	71	87	106	126	147
40%	0	2	4	8	12	18	24	31	40	49	59	71	83
50%	0	1	3	5	8	11	15	20	25	31	38	45	53
60%	0	1	2	3	5	8	11	14	18	22	26	31	37
70%	0	1	1	3	4	6	8	10	13	16	19	23	27
80%	0	0	1	2	3	4	6	8	10	12	15	18	21
90%	0	0	1	2	2	3	5	6	8	10	12	14	16
100%	0	0	1	1	2	3	4	5	6	8	9	11	13

Sample size determined by:

1- Type of sampling

2 – COV

3 –Expected Reduction

"Differences in Means" can be determined from the CCT

= % Improvement

SAMPLE SIZE REQUIRED IN EACH GROUP FOR THE CROSS-SECTIONAL TEST METHOD

	Pooled CV of measurements												
Detectable difference in means	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	1	1.1	1.2	1.3
10%	16	63	142	251	393	565	769	1005	1272	1570	1900	2261	2653
20%	4	16	36	63	98	142	193	251	318	393	475	565	663
30%	2	7	16	28	44	63	86	112	142	175	211	251	295
40%	1	4	9	16	25	36	48	63	80	98	119	142	166
50%	1	3	6	10	16	23	31	40	51	63	76	91	106
60%	1	2	4	7	11	16	22	28	36	44	53	63	74
70%	1	2	3	5	8	12	16	21	26	32	39	46	54
80%	0	1	2	4	6	9	12	16	20	25	30	36	42
90%	0	1	2	3	5	7	10	13	16	20	24	28	33
100%	0	1	2	3	4	6	8	10	13	16	19	23	27

Where to find the detailed tests

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