Controlled Cooking Test

(Revised November 2025)

Introduction

The Controlled Cooking Test (CCT) is a field test used to measure cookstove performance in a controlled setting using local fuels, pots, and cooking practices, with local cooks preparing a pre-determined local meal. The CCT may be used to compare the performance of multiple cookstove types.

This protocol aims to minimize the influence of other factors, enabling the test conditions to be reproduced while still reflecting real-world cookstove use. Testing should include repetitions of the CCT for each cookstove being compared, ideally with each cookstove tested three times by each of three or more cooks.

CCTs should be performed in the country where the cookstoves are used. To ensure that testers can control the testing environment, tests should be conducted in a controlled setting such as a lab, testing center, or workshop. The testing location should be protected from wind, which can impact results. Tests should not be carried out in private households.

Required Equipment

The equipment required to conduct a series of CCTs includes:

- **Cooking pot(s)**: CCTs should use the cooking vessels (typically pots) most commonly used in the test location, region, or country. If a pot does not fit one or more of the cookstoves being tested, testers should use the most appropriate pot and record its specifications in the Data and Calculation form. For cooking technologies that require specific pot compatibility (e.g., induction stoves and electric pressure cookers), manufacturer specifications should be followed. Whenever possible, the same type of pot (size, shape, and material) should be used to test all cookstoves. Pot lids should be used if they are commonly used by local cooks.

- **Fuel mass/energy measurement instrument(s)**, including weighing scales, flow meters, and power meters: All instruments used to measure fuel or energy inputs should have sufficient capacity for the amount of fuel required for the CCT, and should provide the resolution and accuracy needed to detect changes equivalent to 1% or less of the total fuel or energy consumption expected during a typical CCT. Instruments should be calibrated against known or certified standards before the CCTs and checked daily during testing.

- **Scales:** Used for solid or liquid fuels such as wood, charcoal, pellets, or LPG cylinders. *Example*: For a CCT using ~1 kg of wood (~15 MJ of energy), the measurement device should resolve 10 g or better to maintain accuracy within 1% of total fuel use.
- **Flow meters:** Used for gaseous fuels such as biogas or piped LPG. Flow meters should be rated for the expected flow range and gas composition. *Example*: For a biogas test using ~20 MJ of energy, the flow meter should be capable of detecting changes of ~0.2 MJ. With a typical lower heating value of 200 MJ/m^3 for biogas, 0.2 MJ corresponds to ~1 liter (0.035 standard cubic feet).
- **Electricity power loggers:** Used for electric cookers. Power or energy meters should record instantaneous and cumulative energy use. *Example*: For an electric cooker drawing ~10 MJ of energy (~2.8 kWh), the meter should record cumulative energy use with a resolution of 0.06 kWh or finer.

- **Additional equipment:**
  - **Heat-resistant pads** for protecting scales when weighing hot materials such as charcoal.
  - **Oven** capable of regulating temperature to 5-10°C above the local boiling point for determining the moisture content of solid fuels. For woodfuel, a pin-style electrical resistance moisture meter may be used if calibrated with the oven-drying method.
  - **Timer** for measuring the duration of tests.
  - **Thermometer** for recording ambient temperature; food temperatures are not recorded.
  - **Small shovel or spatula** for removing charcoal from the cookstove for weighing.
  - **Dust pan** for transferring charcoal.
  - **Metal tray** to hold charcoal for weighing.
  - **Heat-resistant gloves**.

CCT Testing Procedure

CCT planning

Step 1: Convene a representative group of cooks

The first step in planning a CCT is to select at least three experienced cooks from the community(ies) where the cookstove will be deployed. These cooks will help identify a standard meal that is both culturally relevant and technically suitable for standardized comparison across cookstove types. Cooks should be selected to represent the diversity of households in the test region and to reflect variation in cooking practices.

They should be individuals who regularly prepare the main household meal using the locally dominant cooking technology(ies). The consultation should take place in a neutral, structured setting such as a community meeting space or the test facility itself.

Step 2: Facilitate a discussion to define a standard meal

Test facilitators should guide the cooks in identifying a meal that is widely consumed within the community, including dishes that require a range of common cooking techniques (e.g., boiling, frying, roasting), and are prepared at the meal when the greatest quantity of food is typically consumed. Cooks should describe the size and composition of a “typical” family meal (e.g., sufficient for two adults and two children) in quantitative and qualitative terms.

Step 3: Document the standardized cooking procedure

Test facilitators should prepare a detailed written description of the cooking process, including mass of each ingredient (example shown in table below), sequence of preparation steps, duration, and any observable cues for determining completion. The documentation should be reviewed by all participating cooks to ensure it accurately reflects local practices and can be replicated consistently by any trained cook or tester.

Example of food used in a CCT
(adapted from Baldwin, 1987, p. 94)

Dish	Ingredient	Quantity (g)
Porridge	water	4000
	millet flour	1000
Sauce	oil	100
	meat	450
	tomatoes	300
	water	2500
	onions	70
	spices	50

Step 4: Procure sufficient ingredients and fuel

Once the standard meal has been defined, ensure that adequate quantities of food, water, and fuel are procured for all planned CCT repetitions, including a margin for aborted or repeat tests. Where possible, ingredients should be obtained from a single source or batch to ensure homogeneity across test runs.

Fuel: Testers should use local input to determine the quantity of fuel required to cook the standardized meal on a traditional cookstove. A homogeneous mix of fuel should be procured in advance in sufficient quantity for all CCTs, and biomass fuel should be air-dried. Assume that each cookstove will be tested at least three times and allow for a significant margin of error.

For example:
If local cooks report that a standard meal requires ~2.5 kg of fuelwood and three cookstoves are to be tested, the full set of tests will require:

$$2.5\ kg/meal\ \times\ 3\ stoves\ \times\ 3\ tests/stove\ \times\ 3\ cooks \times\ 2$$

The final factor of two is included to allow for aborted tests and other contingencies. This totals approximately 135 kg of wood. To save time during testing, the fuel may be divided into pre-weighed bundles.

Food and water: Testers should ensure they have enough water and all required ingredients for the full set of tests, with extra to accommodate any repeated or aborted test runs. As with fuel, food ingredients should be homogeneous so that variability in the ingredients does not bias test results. Dishes, utensils, cutting boards, and knives needed for ingredient preparation should also be procured in advance.

Specific applications: For cookstoves designed for specialized applications, such as tortilla or chapati production, the standardized cooking task may require smaller or more repetitive operations rather than a full meal. In such cases, testers should define the task and the corresponding food quantity in consultation with local cooks to ensure it reflects normal cookstove use conditions.

For institutional or large-scale cooking, the same principles apply, but meal size, fuel quantity, and cooking vessel dimensions should be scaled proportionally to reflect typical practice. Where possible, the number of portions prepared should correspond to the average number of people served per meal in the intended setting. In many institutional contexts, multiple baseline cookstoves are used simultaneously to prepare the same quantity of food that a single improved cookstove can handle. In such cases, the quantity of food prepared on the baseline cookstove may be scaled down accordingly.

Step 5: Recruit and train local cooks

The cooking for the CCT should be performed by local individuals who are familiar with both the selected standard meal and the operation of the cookstove(s) being tested. Ideally, these cooks will be the same participants involved in the facilitated discussion

and preliminary trials used to determine the standard meal, as they are already familiar with the specific ingredients, quantities, and cooking methods that have been standardized for the test.

If there are logistical or technical constraints preventing local cooks from participating directly, a trained laboratory technician or research assistant who is knowledgeable about local cooking practices may perform the tests. However, priority should always be given to engaging local cooks to ensure that the cooking process remains authentic and representative of real-world cookstove use.

Before the CCT begins, all cooks should be trained on the finalized testing procedure to ensure consistency and reproducibility across cookstoves and test repetitions. The training should include:

- **Review of the standardized meal specification:** Cooks and testers should jointly review the meal composition, number of dishes, and precise quantities of all ingredients and water to be used.
- **Training on new or improved cookstove technologies:** All cooks should receive hands-on training on the operation of each cookstove being tested, regardless of its similarity to local traditional designs. Training should cover safe operation, lighting and startup procedures, heat or power level control, fuel handling, and any manufacturer-specific operating steps. This ensures that all cooks can use each cookstove confidently and consistently before formal testing begins.
- **Familiarization with the standardized cooking procedure:** A detailed, step-by-step cooking procedure should be provided to all cooks, including preparation steps, timing, and objective indicators for determining when the food is fully cooked (e.g., “beans have split, and skins loosened” rather than “beans taste ready”). The procedure should be reviewed and, if necessary, demonstrated until all cooks can confidently reproduce it without deviation.
- **Practice sessions and final updates:** Each cook should complete one or more supervised practice runs on the assigned cookstove type prior to formal testing. These sessions help ensure safety and consistent technique across cooks and cookstove types. They also provide a final opportunity to make minor adjustments to the standardized meal procedure (e.g., adjusting utensil needs, clarifying steps, or refining recipe details based on cook feedback). After these sessions and any agreed adjustments, the meal and procedure should be fixed for all subsequent tests.

Step 6: Determine testing schedule

To prevent bias, each cook-technology combination should be done in equal numbers, and cookstove models should be rotated. The cookstove type order should change for each test block to ensure that no cook consistently follows the same cookstove sequence, as demonstrated in Figure 1, which provides example cookstove and fuel types.

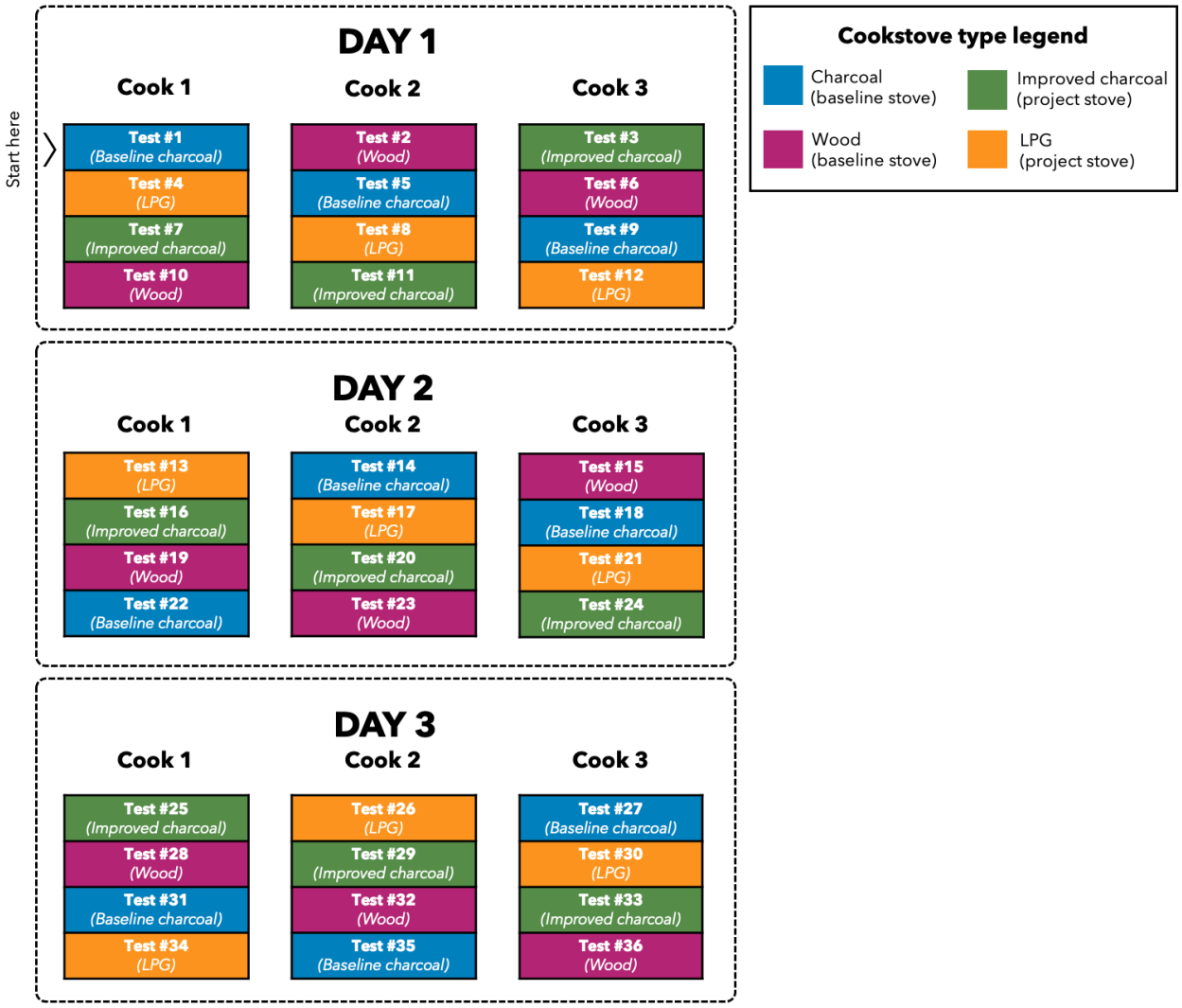


Figure 1. Minimum Testing Configuration and Example Schedule for CCT.

CCT implementation

Several variables should be directly measured during the CCT, including environmental variables (e.g., wind condition and air temperature) and physical test parameters (e.g., wood moisture content, empty pot weight, fuel quantity, etc.). Environmental variables may vary slightly from one test to another but should be nearly constant. Physical test parameters should be constant for all tests.

CCT implementation steps are as follows:

Step 1: Record local conditions

Record local conditions as instructed on the Data and Calculation form. This includes both fuel characteristics and environmental conditions.

Step 2: Prepare the ingredients

Weigh and prepare (wash, peel, cut, etc.) all the pre-determined ingredients according to the standardized cooking procedure described in Step 5 above. Non-perishable food may be prepared in bulk for all the tests.

Step 3: Prepare the fuel

Start with a pre-weighed quantity of fuel that is roughly double the amount local cooks consider necessary to complete the cooking task. Measure the initial mass of each cooking vessel, the initial mass of uncooked food, and the initial mass of each fuel type and record the results on the Data and Calculation form. Fuel types should be distinguished according to their heating value. Examples of fuel types include biomass species or other fuel materials such as kerosene.

Step 4: Collect fuel data

If using a hand-held moisture meter for wood fuels, measure and record the moisture content. To do so, take three moisture meter readings from three randomly selected sticks, measuring at both ends and the center. Align the moisture meter pins with the grain of the wood and avoid bark if possible. Insert the pins, count to five, and then record the reading.

Collect a representative sample of each fuel type in sealed containers for later laboratory analysis of moisture content and heating value.

Step 5: Start cooking

Starting with a cookstove at ambient temperature, instruct the cook(s) to begin cooking in a way that reflects local practices. For clean fuels, this may involve simply turning a switch. For woodfuels, this may involve using some kind of fire starter like paper or paraffin (kerosene) or placing a portable cookstove outside to allow for better ventilation during a smoky start-up phase. Start the timer and record the start time on the Data and Calculation form.

Step 6: Record observations

While the cook performs the cooking tasks, record any relevant observations and comments that the cook makes or difficulties they encounter (e.g., excessive heat, smoke, instability of the cookstove or pot, etc.).

Step 7: End cooking and record end time

When the cook indicates that the cooking tasks are finished, record the end time of cooking in the Data and Calculation form (see guidance above on determining when the

task is complete).

Step 8: Weigh cooked food

Remove the pot(s) from the cookstove and weigh each pot with its cooked food on the balance. Record the weight in grams on the Data and Calculation form.

Step 9: Account for remaining fuel

For wood, charcoal, or other biomass cookstoves, instruct the cooks to either extinguish the fire or let the fire burn out as they normally would. Weigh any unburned fuel from the cookstove with the remaining fuel from the original quantity, but not any remaining coals. Record the measurement on the Data and Calculation form, along with the time of the final fuel measurement.

Step 10: Conclude test

Once the test is complete, the cooked food and any remaining ingredients may be consumed or distributed to any willing audience to avoid waste, as long as doing so does not interfere with the CCT procedures.

CCT Analysis

Of note: the specific energy consumption measurement outlined in this protocol is adapted from ISO 19869:2019, with the following key changes:

- Specific energy consumption is calculated with a simplifying assumption that any char remaining at the end of a cooking session is not saved for later use.
- The test may be conducted in either a laboratory or a workshop (not a household setting).
- The oven-drying method is recommended as best practice for measuring moisture content.
- Minor clarifications are added.

Calculation measurements

The calculations are based on the following measurements:
a) mass of each fuel type consumed
b) energy content of each fuel type (lower heating value)
c) moisture content of each solid fuel type. The oven-drying method is considered best practice. For woodfuel, a moisture meter may be used if calibrated with the oven-drying method.
d) initial empty mass of each cooking vessel
e) initial mass of uncooked food, including water (to ensure consistency across tests)
f) final mass of each cooking vessel with cooked food

Energy consumption calculation

Energy consumed is defined in Formula (1) as the total fuel energy used, with the simplifying assumption that any char remaining at the end of a cooking session is not saved for later use.

$$E_{fuel} = \sum_{type} \left[\left(M_{type,i} - M_{type,f} \right) \times LHV_{type,af} \right] \quad (1)$$

Where:

Parameter	Description	Unit
E_{fuel}	Total energy consumed	MJ
$M_{type,i}$	Initial mass of each fuel type	kg
$M_{type,f}$	Final mass of each fuel type	kg
$LHV_{type,af}$	Lower heating value of each fuel type, as fired	MJ/kg

Specific energy consumption calculation

$$SC_{energy} = \frac{E_{fuel}}{M_{food}} \quad (2)$$

Where:

Parameter	Description	Unit
SC_{energy}	Specific energy consumption	MJ/kg
E_{fuel}	Total energy consumed for all fuel types	MJ
M_{food}	Total mass of food cooked	kg

Aggregated results

The specific energy consumption metric should be tabulated for all test replicates performed on each cooking technology. There should be a minimum of 9 test replicates for each cooking technology (3 cooks × 3 replicates per cook).

The mean, standard deviation, and coefficient of variation of the specific energy consumed (SC_{energy}), should be calculated for the cooking technology #1 and cooking technology #2 test replicates.

To calculate the percent difference of the two sample means, Formula (3) should be used:

$$\%diff = \frac{mean(SC_{energy,2}) - mean(SC_{energy,1})}{mean(SC_{energy,1})} \times 100\% \quad (3)$$

Where:

Parameter	Description	Unit
$SC_{energy,1}$	Specific energy consumption of cooking technology #1;	MJ/kg
$SC_{energy,2}$	specific energy consumption of cooking technology #2	MJ/kg

This calculation provides the percent difference in specific energy consumption of cooking technology #2 compared to cooking technology #1. A negative value indicates technology #2 had a reduction in energy consumption compared to technology #1.

Reporting

Reporting metrics (specific consumption and cooking time) should include 95% confidence interval estimates (see Annex 1 for uncertainty guidelines). The following values should also be reported:

a) initial uncooked mass of each type of food;

b) material and empty mass of each cooking vessel;

c) final mass of each cooking vessel with cooked food; and

d) the reporting metric of specific energy consumption.

An example specific energy consumption reporting template is provided in Annex 2.

Annex 1. Reporting uncertainty and statistical analysis (recommended approaches)

Uncertainty and confidence intervals

Specific energy consumption and total cooking time should be reported with 95% confidence interval (CI).

- Calculate the mean, standard deviation (SD), and standard error (SE = SD / √n) for each cookstove type.
- The 95% CI is:
  $mean \pm t_{0.975,df} \times SE$,
  where $t_{0.975,df}$ is the two-tailed t-value for the sample size.
- Present results in both tabular and graphical form (mean ± 95% CI).

Sample size (n)	Degrees of freedom (df)	$t_{0.975,df}$
3	2	4.303
4	3	3.182
5	4	2.776
6	5	2.571
7	6	2.447
8	7	2.365
9	8	2.306
10	9	2.262
12	11	2.201
15	14	2.145
20	19	2.093

Statistical comparison of cookstoves

To compare two cookstove types, use a two-sample t-test (assuming unequal variances, t-test).

- Report the mean difference, percent difference, 95% CI of the difference, and the *p*-value.
- A *p*-value < 0.05 is typically considered statistically significant, but interpretation should focus on the magnitude and direction of the effect.
- If more than two cookstove types are compared, use pairwise t-tests with a simple correction (e.g., Bonferroni) or report the overall ANOVA *p*-value.

Quality assurance and data checks

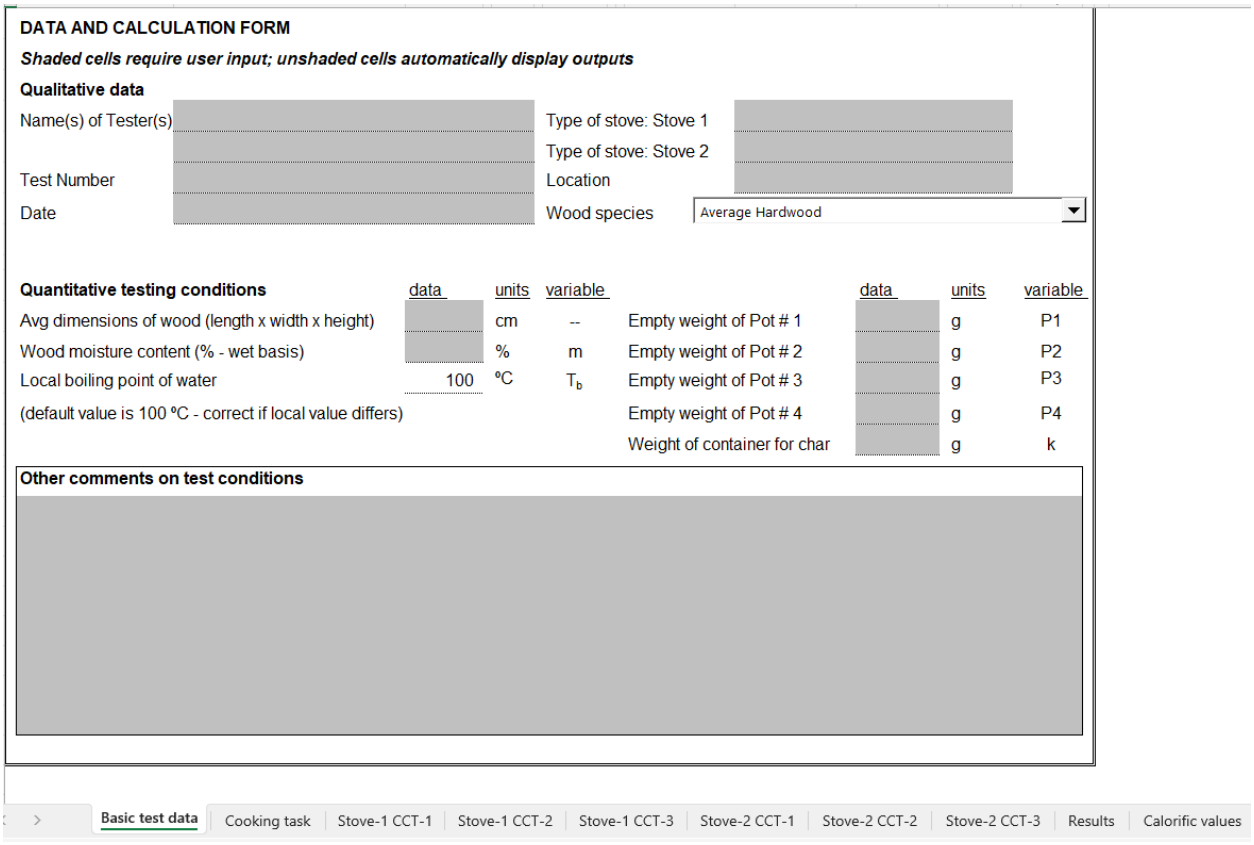
Before analysis, confirm:

- All instruments were calibrated and within the required accuracy range.
- Recorded energy or fuel consumption values are physically reasonable (for example, electric power does not exceed the cookstove's rated capacity, and total energy use is positive).

- Outliers or anomalous values are reviewed and either corrected or clearly noted with justification.
- Firepower and cooking times are consistent with expected ranges for the meal size and cookstove type.

Annex 2. Reporting template/example

The CCT data calculation form spreadsheet can be found at https://cleancooking.org/protocols/.



DATA AND CALCULATION FORM

Shaded cells require user input; unshaded cells automatically display outputs

Qualitative data

Name(s) of Tester(s)		Type of stove: Stove 1	
		Type of stove: Stove 2	
Test Number		Location	
Date		Wood species	Average Hardwood

Quantitative testing conditions	data	units	variable		data	units	variable
Avg dimensions of wood (length x width x height)		cm	--	Empty weight of Pot # 1		g	P1
Wood moisture content (% - wet basis)		%	m	Empty weight of Pot # 2		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		g	k

Other comments on test conditions

Basic test data | Cooking task | Stove-1 CCT-1 | Stove-1 CCT-2 | Stove-1 CCT-3 | Stove-2 CCT-1 | Stove-2 CCT-2 | Stove-2 CCT-3 | Results | Calorific values