Monitoring stove performance

A chimney stove routes pollutants to the outside

It is often stove performance that determines whether a given intervention is adopted or not, and whether it is used and maintained appropriately. As a minimum, an improved stove must meet the users' needs as well as the fire or stove that was used initially. Beyond this, stoves should decrease the amount of fuel needed and make the cooking task easier.

The Stove Performance Monitoring Module is laid out in three steps. First, participants are introduced to the criteria for evaluating stove performance and the various methods to determine performance. Secondly, the module looks at the principles behind the creation of a better stove. Finally, participants get experience in undertaking a test as part of a practical exercise.

Stove performance criteria

Six criteria are important for evaluating stove performance: efficiency, specific consumption, turn down ratio, speed of cooking, user satisfaction and emissions.

Efficiency: This is the most commonly used criterion for comparing stoves. Efficiency is determined by dividing the amount of energy trapped in a pot by the amount of energy burned in the stove. The amount of energy trapped in the pot is calculated by measuring the rise in water temperature and the amount of water turned into steam. While this is a useful concept for evaluating stoves, numbers can be misleading as they reward a stove for producing an excess of steam.

Specific consumption: This is the most useful criterion for determining how much fuel a stove is likely to consume. Specific consumption is defined as the amount of fuel it takes to perform a specific task, for example, the amount of fuel consumed per litre of water boiled or food cooked.

Turn down ratio: This is also known as control efficiency, determined by the difference in fuel consumption per minute between high power (bringing water to a boil) and low power (simmering). Stoves with a higher turn down ratio are likely to use less fuel during a real-life cooking task, which involves bringing food to a boil and then cooking it at a simmer for an extended period of time.

Speed of cooking: This is mostly a measure of user friendliness. Speed of cooking is specified as the time it takes to boil or cook a given amount of food, generally per litre. However, cooking time also tends to be the time a cook spends near the stove and thus determines duration of exposure to indoor air pollution.

User satisfaction: This represents a subjective but important criterion, as user satisfaction determines stove adoption and use. Stoves are frequently chosen because they cook well and not because they save fuel or emit less pollution. We gain an idea of user satisfaction by surveying local use of the stove.

Emissions: Standard emissions criteria and methods to assess them are not yet available but in the process of being developed. Out of all the performance criteria, stove emissions are most directly related to indoor air pollution levels and thus health.

Stove performance tests

Following a brief overview of the development of stove performance testing, this section describes the protocols for conducting and analyzing three commonly used tests: the Water Boiling Test, the Controlled Cooking Test and the Kitchen Performance Test.

Water Boiling Test: This lab-based test attempts to simulate the most common cooking modes of a stove while keeping other factors constant to make the results as comparable as possible between different projects. The test consists of three phases, each representing a particular cooking

situation: (1) bringing water to a boil with a cold stove; (2) bringing water to a boil with a hot stove; and (3) simmering water with a hot stove. The results relate to four of the six performance criteria: efficiency, specific consumption, time to boil and turn down ratio.

Controlled Cooking Test: This lab-based test involves local cooks preparing a local dish. Adding these variables limits comparability of results to a given setting but provides important feedback as to the likely acceptability of a stove by local users. The results relate to specific consumption, speed of cooking and user satisfaction.

Kitchen Performance Test: This is the most difficult and resource-intensive test. It consists of a survey and a fuel consumption test with families using both the traditional and the improved cook stove. The test gives results of user satisfaction and per capita fuel consumption for a given stove. As the test encompasses many different variables, often a large number of tests need to be performed to assure statistical accuracy in the results.

Stove design criteria

Design criteria are important for improving stove performance, and design solutions exist for creating stoves that succeed in improving all six performance criteria. Two design criteria must be met to create a stove that uses less fuel and produces less pollution: improving fuel combustion (combustion efficiency) and directing more of the heat into the pot (heat transfer efficiency). High combustion temperatures and good mixing of gases, air and fire reduce dangerous emissions through more complete combustion. Forcing the heat to scrape against the pot in small channels dramatically increases heat transfer efficiency, thereby reducing the fuel used for cooking.

The presentation explains in detail the various factors that affect combustion and heat transfer efficiencies. It concludes with a description of ten stove design principles used by indigenous teams around the world to create appropriate technologies that meet local requirements.

At the end of the module participants perform a water boiling test to put into practice the protocols and to try out the analysis of the results.

Traditional mud stove in India

Charcoal stove in Sudan

Improved plancha stove in Guatemala