Biomass Cookstoves
Standards, Certification and R&D Experiences from India

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Historical Profiles
International Testing Protocols

- **Prasad, Verhaart and Visser:** During the 1970s and 1980s there were several key individuals, including **Dr. Krishna Prasad**, **Dr. Peter Verhaart** and **Dr. Piet Visser,** from Eindhoven University, who were instrumental in designing the first stove testing protocols (known as the VITA protocols) that are used globally in revised form today.

- **Dr. Samuel Baldwin:** In addition to important technological design information, Dr. Samuel Baldwin's 1987 work, biomass Cookstoves: Engineering Design, Development and Dissemination, provided detailed, revised stove testing protocols that became standard practice for more than a decade.

- **Shell Foundation HEH Project:** After nearly two decades of use, the VITA protocols were updated (2003- 2007) thanks to the Household Energy and Health (HEH) Project, supported by a Shell Foundation grant. These efforts were headed by Dr. Kirk Smith of UC Berkeley, Dr. Rob Bailis of Yale University, Dr. Rufus Edwards from UC Irvine, and Dean Still, Damon Ogle and Nordica McCarty from Aprovecho Research Center, among others.

Water Boiling Test, version 4.1.2

- Starting in 2007, Version 3 of the WBT was evaluated and revised by a subcommittee of Engineers in Technical and Humanitarian Opportunities of Service (ETHOS) under the leadership of Dr. Tami Bond. Through electronic communication, twenty-two people from 11 countries provided input to identify and resolve technical inaccuracies and challenges in the WBT, and recommend emission testing procedures. Their efforts are reflected in the new WBT protocol “Emissions and Efficiency in a Controlled Laboratory Setting.”

EMISSIONS AND PERFORMANCE TEST PROTOCOL (EPTP) BACKGROUND

- In April 2009 Envirofit and Philips agreed to jointly develop a refined version of WBT 3.0 more suited to the needs of large scale manufacturers
- Focus on repeatability
- Focus on emissions taken per existing accepted protocols
- Goal of going to an ISO standard
- Parametric testing completed at Colorado State University's Engines and Energy conversion lab to determine what variables need to be controlled
- Revision of the document to improve readability/useability
- Released in October of 09

EPTP Conclusions

- Emissions & Efficiency/TTB can not be tested asynchronously.
- Accurate emissions testing is possible, but requires
  - controlled hoods
  - calibrated and accurate emissions equipment
  - accurate exhaust flow measurement
- To have reasonable confidence multiple test (6-8 minimum) are required
- The addition of a foam to the top of the pot reduces vapor release variability
- Keeping the same ΔT but shifting the temperature range to prevent boiling reduces variability
- Controlling wood dimensions and moisture content reduces variability
- Controlling ambient conditions provides further variability control but is impractical in most cases and not included in the EPTP

Chinese standard WBT

- The procedures developed by the State Standards Organization of the People's Republic of China - "Testing Method for the Heat Properties of Civil Firewood Stoves". The largest improved stoves program to date was conducted by the Chinese’government through the National Improved Stove Program. The *Testing Method for the Heat Properties of Civil Firewood Stoves* calls for taking a standard amount of fuel and heating a pot of water to boil and then allowing that pot to simmer until a simmer cannot be sustained.

Comparative Water Boiling Test (CWBT):

This is an adaptation by Jean-François Rozis of the test method and procedure of the international standard

Water Boiling Test (WBT), modified to account for the real customs and habits of cooking in Cambodia. CWBT is only for comparing stoves' Potential Fuel Savings under similar conditions of use, which eliminates error sources from fuel heat value calculations.

The CWBT is designed to duplicate as closely as possible real cooking conditions. As well, the CWBT is designed to be simple – it requires minimum equipment easily available in Cambodia and is easy to conduct in the field. The CWBT also simplifies the calculation at the end of the test.

Indian Standard WBT

- The procedures developed by the Bureau of Indian Standards, for measuring the efficiency of the cookstoves. In 1983 the Indian government, through the Department of Non-Conventional Energy Sources (DNES), began a program to promote the introduction of improved biomass stoves. Started by the DNES, the National Programme on Improved Chulhas (NPIC) was seeking to reduce fuel use, limit deforestation, and improve air quality in the home. As part of the program the Bureau of Indian Standards (BIS) developed a certification process for biomass stoves. The BIS protocol calls for using a set amount of fuel, based on stove heat production rate, and determining the amount of thermal energy which can be transferred to a cooking pot. The stove is lit and pots of water are heated to just below the boiling point and then replaced with pots with fresh water until all fuel has been consumed.

Present Status

Because of the diverse stove-improvement initiatives moving forward in tandem, however, to date no single governing standard for comparing stove performance has emerged.

Criticism of the Water Boiling Test

- According to the Eindhoven Woodburning Stove Group (as described on http://www.cookstove.net/others/fuel-economy.html), the Water Boiling Test has the following weaknesses.
- Recovery of the charcoal is not sharply defined and is therefore operator dependent.
- The charcoal weights are small and measurement of such small weights is always subject to large errors.
- Estimation of the combustion value of charcoal, produced in a wood fire is at best a tricky task.
- A lot of things must be done in as short a time as possible between the high-power and the low-power phase, so the risk of making mistakes or mis readings is pretty high.

Steady-state Water Boiling Test

Prasad of the Wood burning Stove Group believe that for laboratory work on wood-stove research and development a more engineering-oriented attitude must be taken than used in the standard Water Boiling Test.

"A woodstove can be characterized by an efficiency-versus-power graph. The efficiency figures for a pan-stove combination should be established by steady-state water-boiling experiments. For woodstoves, the best we can hope for is periodic steady state. And the water boiling test then is no longer a simulation of food-cooking process, with the water replacing the food, but instead the measurement of a heat transfer process, with the water as a convenient medium to measure the heat transfer from the fire to the pan."

Benefits and limitations of the WBT

- The WBT test for efficiency can be performed throughout the world with simple equipment. (If emissions are measured, more complex equipment is required.) Its primary benefits are:
  - Provide an initial assessment of stove performance
  - Compare the effectiveness of different designs at performing similar tasks
  - Evaluate stove changes during development
  - Select the most promising products for field trials
  - Ensure that manufactured stoves meet design specifications

- The WBT, on the other hand, is not an accurate way to determine actual fuel use under field conditions or changes in fuel use, for example from introduction of an improved stoves.

Controlled Cooking Test (CCT)

- The controlled cooking test (CCT) is designed to assess the performance of the
- improved stove relative to the common or traditional stoves that the improved
- model is meant to replace. Stoves are compared as they perform a standard
- cooking task that is closer to the actual cooking that local people do every day.
- However, the tests are designed in a way that minimizes the influence of otherfactors and allows for the test conditions to be reproduced.
- Controlled Cooking Test (CCT) v.2.0 with appendices
- Controlled Cooking Test (CCT) data calculation sheet v.2.0 | PDF

Kitchen Performance Test (KPT)

The Kitchen Performance Test (KPT) is the principal field–based procedure to demonstrate the effect of stove interventions on household fuel consumption. There are two main goals of the KPT: (1) to assess qualitative aspects of stove performance through household surveys and (2) to compare the impact of improved stove(s) onfuel consumption in the kitchens of real households. To meet these aims, the KPT includes quantitative surveys of fuel consumption and qualitative surveys of stove performance and acceptability. This type of testing, when conducted carefully, is the best way to understand the stove's impact on fuel use and on general household characteristics and behaviors because it occurs in the homes of stove users (Lillywhite, 1984; VITA, 1985). However, it is also the most difficult way to test stoves because it intrudes on people's daily activities. In addition, the measurements taken during the KPT are more uncertain because potential sources of error harder to control in comparison to laboratory-based tests. For this reason, the protocol for the KPT is quite different from the protocols for the Water Boiling Test (WBT) and the Controlled Cooking Test(CCT).

- Kitchen Performance Test (KPT) v.3.0 with appendices
- Kitchen Performance Test (KPT) data calculation sheet v.3.0 | PDF

Existing Cookstove Standard Worldwide [30]

	Designation Name	Topic1		Focus2		Test method/s	Indicators	Max/min values	Comments
		Performance	Method	Efficiency	Emision				
China	(No designation) Standard for Biomass molded fuel (Draft)	x		-	-	Unknown	Unknown	Unknown	Beijing municipal standard for solid fuelsscheduled for publication Q2 2008
India	**IS 13152 (CIS 1315 Z) (Part 1): 1991** Indian Standard on Biomass Chulha-Specification	x	x	x	X	Water boiling test (Thermal Efficiency), stove hood for emissions tests	Thermal efficiency, CO/CO_2 ratio, TSP	CO/CO_2 ratio less than 0.04, TSP less than $2mg/m^3$	First national test methodology designed specifically for cookstoves
Uganda	**DUS 761:2007** (Draft)	x	x	x		Water boiling test	PHU (% of heat utilized)	>30% PHU @ 3kW power output, Thermal shock resistance, external temp. ≤ 45o C	Draft standard is based on Kenyan Jiko design. Emissions not included in standard.

Existing Cookstove Standard Worldwide [30]…

Kenya	**KS 1814**	-	-	-	-	unknown	unknown
South Africa	**SABS 1111-1976** (Coal burning domestic appliances)	x	x	x	x	Water boiling test, kitchen performance test (cooking test), stack measurement (smoke)	Time to reach temperature, heat distribution, obscuration (smoke)
South Africa	**SANS 1243:2007**, Ed. 3 (Pressurized paraffin-fueled appliances)	x	x	x	x	Combustion efficiency test ($CO:CO_2$ ratio), thermal output (kW, calculated from fuel consumption), smoke hood and stack measurements	$CO:CO_2$ ratio (combustion efficiency), Power output (kW) averaged over 600 seconds burn time, (thermal output)
South Africa	**SANS 1906:2006** Ed. 2.1 (Non-pressure paraffin stoves and heaters)	x	x	x	x	Fuel consumption (thermal efficiency), smoke hood and stack measurements (emissions)	Power output in kW averaged over 7.5 hours burn time, particulates and $CO:CO_2$ ratio

Shell Foundation's Standards Mostly Followed by Different Groups Presently

	3 stone fire	Shell Foundation	Percentage Reduction
CO	100 g	20 g	80%
PM	4800	1500 mg	69%
Wood Consumption	2000 g/hr	800 g/hr	60%

Indian Initiative-Past…

- A total of 33.8 million improved chulhas installed by 2004 with varying degree of success in different regions in the country.
- Some models had better acceptability than others in specific regions.
- Certain regions showed greater enthusiasm on the part of the users to adopt new designs.
- For a variety of reasons the programme brought a mixed bag of experiences.
- The programme was formally declared closed in 2004.

New Initiative

- Need for a new initiative – brainstorming session in March 2009
- An joint project to IITD and TERI for working out the contours of the new initiative (October 2009-May 2010).

Objectives-

To advise MNRE on the action plan for the new cookstoves initiative covering the following

- Technical Aspects (R&D, Testing)
- Delivery of Cookstoves
- Fuel Processing and Supply
- Global Innovation Contest
- Community Stoves
- Implementation Strategies

New Initiative…

- Several brainstorming sessions and consultations with a range of stakeholders and experts from civil society, academia, business, and government to develop an understanding of current activities and future potential of such a programme.
- The programme launched on 2nd October 2009 by MNRE.
- Aims to distribute approximately 150 million high efficiency stoves in the next 15 years.
- Aims to achieve quality of energy services from Cookstoves comparable to that from other clean energy sources such as LPG.

Final report

- “The Final Report titled “New Initiative for Development and Deployment of Improved Cookstoves: Recommended Action Plan”. Submitted in July 2010.

Recommendations- General

- Need to learn from strengths and weaknesses of NPIC, but based on the recognition that that Cookstoves technology has improved considerably in the past few years, and further advances are still possible, indeed essential.
- Desirable to have a different management and implementation structure for the new initiative although it will build on the several successes of that programme while also drawing lessons from the experience gained from its implementation.

Recommendations…

Need for carrying out the initiative in two phases

- Phase I
  - Pilot dissemination (various delivery models, fuel processing units)

    A series of pilot-scale projects envisaged using several existing commercially-available and better Cookstoves and different grades of processed biomass fuels. This will help in exploring a range of technology deployment, biomass processing, and delivery models leveraging public-private partnerships.
  - Will set in motion a series of activities that are designed to develop the next-generation of household Cookstoves, biomass-processing technologies, and deployment models, including-

Recommendations…

- An innovative global contest to develop combustion units with high thermal efficiency and low pollution characteristics.
- Appropriate biomass-processing devices.
- Enhancement of technical capacity in the country by setting up state-of-the-art testing, certification and monitoring facilities and strengthening R&D programmes in key technical institutions.
- An independent monitoring and evaluation component envisaged to assess the activities and fine-tune them on an ongoing basis.
- It will welcome and promote participation by civil society and private actors to make it a true public-private partnership.

➢ Phase II

- Full scale dissemination

Action/ Activities Undertaken

- A steering committee setup under the chairmanship of Member(Energy), Planning Commission of India.
- Decided to setup a Section 25 company under public private mode to implement the programme.
- An MoU signed with X-Prize Foundation of USA to conduct the global contest during the next two years or so.

Action/ Activities Undertaken…

- Four Testing and Evaluation Centres in four different regions- North(IIT Delhi), South(IISc Bangalore), East(IMMT Bhubaneswar), West(MPUAT Udaipur).
- Objectives: Development of standards, protocols, testing of stoves and provide training and technical backup to the stove programme in the country.

Action/ Activities Undertaken…

- Pilot Field Testing And Evaluation Of Community Sized Biomass Cookstoves.
- Coordinated and monitored by IIT Delhi and implemented by ten different agencies, a mix of Govt. and NGOs.
- Ten clusters in six different states identified.
- A package of 50 stoves for each cluster, 30 ICDS/ tribal hostels, 10 midday meal schools, 10 commercial setups like dhabas and restaurants.
- Duration 12 months, (starting August 2010)

Proposed Pilot Programme for family size cookstove

- A few thousands stoves planned during next one year.
- Prefabricated, mass manufactured improved biomass cookstoves, made of metals, ceramic, pottery or a combination their of, duly approved by Testing and Evaluation Centres and passing/meeting BIS test standards which will be suitably modified to suit forced draft stoves as well as community size biomass stoves in terms of burning rate so as to get thermal efficiency and emission reductions parameters similar to those recommended by family size biomass stove under BIS till such time improved/ modified biomass cookstoves test standards are not developed and adopted.

Standards and Protocols

- In India, BIS standards developed in 1991 for a particular kind of cookstove.
- Performance standards very limited in scope.
- Testing protocols have thermal efficiency as the main focus.
- Testing facilities need updation and expansion
- Recent developments in technology and Focus on health aspects call for a close look at the above.

Standards and Protocols- Work Plan

Phase I

Need for interim testing protocol to replace BIS protocol

- Adaptation of WBT4.0
- Background work and coordination by an institute in project mode
- A one/two day workshop to finalize the same

To work on long term development of new protocols

- Coordinated project involving various groups
- Due emphasis on emission characteristics
- Specific consideration to gasifier-type and forced draft stoves
- Balance between repeatability and representation of the cooking practices
- Need for technical rigour as well as practical experience

Standards and Testing Facilities

Three types of testing centres proposed

- In R&D institutes for in-house development and training of testing personnel
- Certification centres with testing facilities – independent organisations
- Field testing centres – associated with grassroot level NGOs.
- Centres to be set-up through EOIs/RFPs
- Star-Ratings on the basis of thermal and emissions characteristics and hence health impacts.
- Government support to be linked with star rating

Testing

Phase II

- New protocols in place.
- Star rating standards in place.
- Training of testing personnel from certification and field testing centres by R&D centres.
- Certification centres to carry out testing and certification in accordance with protocols and star ratings.
- Field testing centres to help in evaluation of stoves in the field pilot as well as full scale dissemination.

Research and Development

Need for continuing research on the fundamental scientific principles underlying the design and operation of cookstoves

Different areas of research identified in the report

Phase I

- Call for EOIs for research projects
- Formation of consortia and call for RFPs
- Some institutes may be identified as R&D centres.

Need for an integrated approach - coordinated evaluation of different proposals with the help of an Advisory body.

Possibility of funding by different Ministries and funding organisations.

Research and Development…

Phase II

- Execution of research projects to continue.
- Research activities could lead to development of new products.
- Product development also carried out intuitively by many stove manufacturers.
  - Proposal to facilitate Technical Consultancy Centres which can help in technical analysis of these stove designs and hence their improvement.
  - Particularly important for addressing specific regional cooking needs

Standards and Protocols-Present Status

- The BIS being upgraded and modified to include new developments like forced draft stoves, community stoves, new emissions standards and new testing protocols.
- The first draft prepared and circulated to concerned experts on the subject for their comments and suggestions.
- Comments received and analyzed.
- Recommendations made to BIS accordingly.

Indian Standard

SOLID BIO-MASS CHULHA –SPECIFICATION

Existing	Modifications Proposed
Scope-Family Application	To cover community/commercial applications also
References- Indian Standards referred for construction metallic materials and thermometers,	To include Standard References for Alloys, Ceramic materials, Blowers Capacitors, Batteries, Switches, Electric Wire, Plugs, Thermopiles, LED Lamps, etc.
Terminology, Designs and Types- Only two or three natural draft metallic portable stoves described for guidance. These are- Mild Steel and Cast Iron, All cast iron, Mild steel, cast iron and stainless steel.	Should include more Designs and Types like- Metal ceramic/ceramic/ceramic insulated, Forced draft (mech./ battery operated), Forced Draft with thermopile/thermoelectric devices.

Size- Only domestic stoves of different sizes/ power rating like Small- 0.5 -0.8 kw Medium- 0.8-1.3kw Large- 1.3-1.3kw Extra Large- Above 2.5kw	To include Community/ Commercial Stoves 3-10 kw and Extra Large Stoves Above 10kw. In fact in place of power output, it will be better to categorise stoves on the basis of burning rate (Power Input).
Manufacture and Workmanship defined for various mechanical components.	To include electrical components.
Performance Testing- for natural draft domestic stoves Thermal Efficiency- above 25%. , **CO/C02 Ratio-** less than 0.04,	Domestic Stoves, Natural Draft- As such forced draft- above 40%. Community/ Commercial Stoves Natural draft- above 30%, Forced draft- above 40%. As such. In addition total mass of CO and CO2 to be included.

Total Suspended Particulate- less than 2.0 mg/m3, using handy sampler for one hour with suction of ambient air placed at a distance of 32-45 cm from stove and at a height of 30-37.5 cm from the ground level.	Emissions concentration of particles will depend on the hood flow rate, the location of measurement, to hood features such as doors, air inlets, exhaust pipes, etc. Since hood flow rate will strongly effect the measured concentration of particles in the hood, the total mass emissions should be taken and for that all of the emissions should be collected using an emissions hood and the hood should completely encircle the stove and also be equipped with filters and doors to remove background particles. The hood doors should be opened only for tending the fire. Then it will be simpler and more accurate to sample the particles from the exhaust pipe using isokinetic sampling techniques.

Surface Temperature(at handles) less than 60^{o}c, Cast Iron Components to meet Quenching Test, Stable when tilted to 15 degrees.	To include Electric Appliance Test- Blowers, condensers/ storage battery, wires, plugs, thermopile as per Indian/ International standards.

Procedure- Fuel- *Kaill Deodarl Mango]* *Accasia ,*	 Also Douglas Fir/Pine
pieces of 3 cm x 3 cm square cross-section,	pieces of 1.5cm by 1.5cm square cross-section,
length of half the dia/ Iength of combustion chamber	As such
Burning Rate Determination- Stack the combustion chamber with test fuel in honey comb fashion up to 3/4 of the- height 'or in a pattern recommended by the manufacturer.	Weigh a sample of fuel, let the mass be M1" [g] Stack the combustion chamber with test fuel in honey comb fashion up to the ¾ height or as recommended by the manufacturer.
Sprinkle 10 to I5 ml of kerosene on the fuel from the top of *chulha/ fire box mouth.*	Sprinkle 10 to 15 ml. of kerosene on the fuel from the top of chulha/fire box mouth and light. Simultaneously start the stop watch.
Weigh the *chulha with fuel, let the mass* be *M1 kg.* After half an hour of lighting weigh the *chulha again and let the mass be M2 kg.*	After half an hour of operation remove fuel and extinguish by placing in a metal pot with a tight fitting lid, weight remaining fuel and let the mass be M2[g].

Thermal Efficiency Measurement- A single phase procedure starting with a cold stove and adding fuel in four equal lots after every 15 minutes, heating a measured quantity of water up to 5^{o}c below boiling point and replacing the first vessel after that with a second similar one and keep on repeating till the whole fuel is exhausted and no visible flame in the combustion chamber.	The procedure can be replaced by a three phase one as in WBT 3 or WBT 4 to bring it almost at par with international/ global procedures being considered these days as more appropriate, effective and elaborate procedures, beginning with a Cold Start High Power Phase, followed by a Hot Start High Power Phase and then the Low Power Simmering Phase of 45 minutes. This will also help determine a Turn Down Ratio for the stove.