PARTNERSHIP FOR CLEAN INDOOR AIR (PCIA)

PCIA BULLETIN Regional Stove Testing Centers APRIL 2012 | Issue 30

This quarterly newsletter reports on the activities of the Partnership for Clean Indoor Air (PCIA) and its Partners to improve health, livelihood and quality of life by reducing exposure to indoor air pollution, primarily among women and children, from household energy use. More than 580 Partner organizations are working together to increase the use of affordable, reliable, clean, efficient and safe home cooking and heating practices. Visit **www.pciaonline.org** to join!

As an increasing number of PCIA Partners work to improve the design of their stoves, bring their programs to scale, receive carbon finance, and meet country-specific and internationally recognized standards, there is a greater need for experienced third party testers. That's why it is especially fitting that we have dedicated this milestone **30th edition of the PCIA Bulletin** to providing Partners with information on regional cookstove testing centers.

The testing centers highlighted in Bulletin 30 are located across the globe in North America, Africa, Asia and Latin America. The advice and expertise they provide in this Bulletin stems from thousands of hours of lab and field testing for hundreds of stove designs. We are grateful for their openness and willingness to share their experience with all PCIA Partners.

Each testing center has expressed interest in working with PCIA Partners in their region to test and improve the quality and design of their stoves. As you read through the information in this Bulletin, think about how it relates to your own program and testing needs.

LAST CHANCE
PCIA RESULTS REPORTING!

We've extended the deadline to April 23 to give remaining Partners one last chance to submit their results — don't miss out on your chance to let PCIA and the Alliance know about your 2011 accomplishments and plans for 2012!
http://www.pciaonline.org/results/2011

A full list of regional testing centers is posted on the PCIA website at http://www.pciaonline.org/testing. There you'll also find links to the standard testing protocols, as well as other testing materials and guides. Look for more information throughout this Bulletin on testing resources and exciting new field testing opportunities (such as the CCT/KPT testing announcement on page 4) available to PCIA Partners.

We hope you find this Bulletin and the testing information on PCIA's website to be an important resource for your organization.

In This Issue

FEATURE ARTICLES - REGIONAL STOVE TESTING CENTERS

Testing Centers in North America

U.S. EPA – Cookstove Test Facility

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The mission of the Cookstove Test Facility at Research Triangle Park in North Carolina is to provide independent testing of cookstoves for pollutant emissions and energy efficiency. We tested 14 stove/fuel combinations in a first round of testing in 2007 and tested 44 stove/fuel combinations in a more extensive round in 2010. The U.S. Environmental Protection Agency (EPA) cookstove test facility has worked closely with the Partnership for Clean Indoor Air. We have a full-time Principal Investigator and a full-time Post-Doctoral Fellow working on cookstove research, and we have many EPA and contractor staff working part-time in the testing center. Our focus is on controlled testing in the laboratory, but we are collaborating with PCIA partners conducting field testing as well.

We have tested cookstoves with fuels including wood, charcoal, biomass pellets, rice hulls, corn cobs, and garment waste, and we have plans for testing stoves with additional fuels including LPG, kerosene, and alcohol as well as plans for testing solar cookers. We test stoves that have been disseminated by PCIA Partners all over the world. With our new test facility, we have the capability to test stoves with tall (up to 5m) chimneys, and we will experiment with testing built-in-place stoves. Indicators of stove performance include thermal efficiency, combustion efficiency, fuel use, power, total emissions, and indoor emissions (measured separately for stoves with chimneys). We use the hood method for capturing emissions, and we use real-time instruments for measuring emissions of CO (carbon monoxide), CO_2 (carbon dioxide), THC (total hydrocarbons), CH_4 (methane), NO_X (nitrogen oxides), PM (particulate matter), BC (black carbon), and UFP (ultrafine particles). Additional instruments measure particle light absorption and scattering in real time. We use filter-based measurements for emissions of $PM_{2.5}$ (particulate matter with aerodynamic diameter ≤ 2.5µm), OC (organic carbon), and EC (elemental carbon).

Results of testing are made public through scientific journal articles and through the PCIA website. Results of controlled testing may be used for informing design of cookstoves, comparing performance of stoves under the same operating conditions, benchmarking stoves before field trials, or rating stoves as outlined in the recent ISO International Workshop Agreement (IWA).

New US EPA Cookstove Testing Facility at Research Triangle Park, North Carolina

A few design lessons we have learned (along with other testing centers) are as follows:

- Stoves that are used for cooking only (not for space heating) tend to have better performance when they are designed with small thermal mass (less heat is absorbed by the stove).
- Some forced-draft (fan) and top-lit up-draft (TLUD) stove designs tend to have high performance – high efficiency and low emissions – but usability issues should be considered.
- Compared with the open, 3-stone fire, many cookstoves tested show a bigger improvement with high-moisture fuel than with low-moisture fuel. It is usually better to use low-moisture fuel, but if only high-moisture fuel is available, many cookstoves (such as rocket types) show large improvements over the baseline 3-stone fire.

Common performance pitfalls are caused by problems with materials (such as cracked ceramic or warped metal) and malfunctions (such as problems with a fan speed controller or liquid fuel burner). Continued product development is needed. Performance of some stoves is very dependent on the operator and fuel variables. Processed fuels and batch-loaded stoves tend to have more consistent performance, but usability is again important to consider.

PCIA Partners may have stoves tested at our center through an application process that will be periodically announced to all Partners. Selection of stoves was completed for the next round of testing and is described on page 20 of this PCIA Bulletin. The new ISO IWA "tiers of performance" will be incorporated into this new round of stove testing. We will report results in terms of the measurements specified in the IWA, and we will participate in the continuing development of test protocols for stoves, as recommended in the agreement.

Publication available on PCIA website:

Jetter J, Kariher P. Solid-fuel household cook stoves: characterization of performance and emissions. Biomass Bioenergy 2009; 33(2): 294–305.

Aprovecho: A Regional Stove Development and Testing Center

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Aprovecho Research Center was incorporated in 1976 when six consultants in Guatemala joined forces to build Lorena stoves around the world. When experience showed that the stoves they were promoting were less fuel efficient than the open fire, they started a research center in Oregon and began testing to learn how to make really improved stoves. In the last 26 years, Aprovecho researchers have tested hundreds of stoves and used testing to create optimized performance. Aprovecho has worked with almost every initiative involved with stoves including the Partnership for Clean Indoor Air, the Global Alliance for Clean Cookstoves, GIZ, World Bank, U.S. Agency for International Development, etc. There are currently nine people working at the lab and many other Aprovecho consultants who travel the world helping stove manufacturers. Dr. Larry Winiarski is the backbone of our organization and our mentor.

Aprovecho invented and manufactures both field and lab emission equipment. Developing optimized stoves involves information from the cooks, and from all kinds of testing including laboratory, controlled cooking, production, field and marketing as outlined in chapter five of Dr. Sam Baldwin's book *Biomass Stoves: Engineering Design, Development, and Dissemination*. Stoves that burn liquid fuel, charcoal, biomass, dung, agricultural waste, and/or use sunlight, are all tested and improved at Aprovecho. Our recent publication *Test Results of Cook Stove Performance* http://www.pciaonline.org/files/Test-Results-Cookstove-Performance.pdf compares fuel use and emissions of eighteen cooking technologies using the lab emissions hood (PEMS), results from the Test Kitchen, and the VITA Water Boiling Test (WBT).

Conducting testing on wood stoves under an emissions hood

Aprovecho has tested more than fifty stoves using the WBT which is one of the tests used in the new ISO International Working Agreement (read more about the IWA on page 21). About 20 stoves are tested and improved yearly. Frequently, stove manufacturers send us prototypes that are optimized at our lab using the testing process. Stoves can usually be tested and improved for around $5,000. Testing with an emission hood makes 'tuning up' a stove a pretty straightforward process. A car mechanic can see emissions on a computer screen and make adjustments to the carburetor until the car is clean running. It's the same with a stove. Our lab has also worked for big companies that are developing new and cleaner stoves from scratch. For this type of work we typically spend a year or so on development, which equates to more time and effort and also higher costs. Testing and stove development helps to support the lab and the open source R&D that Aprovecho does every year.

Recording data for three stone fire comparison

We are also doing Test Kitchen testing here at the lab. Testing in a Test Kitchen using the indoor air pollution (IAP) meter in a lightweight backpack measures and records how much CO, CO2, and PM the cook is inhaling. We learn a lot using the Test Kitchen such as how ventilation dilutes emissions, how to make kitchens meet WHO indoor air quality standards, etc. I like the Test Kitchen method because it gets the analysis of fuel use and emissions closer to the reality in a home.

Generally it is simple to improve heat transfer in a cooking stove by just changing its shape which doesn't cost more money. And when less fuel is used, overall emissions are reduced as well. We start improving performance by making the stove as fuel efficient as possible. Then we continue the process by cleaning up combustion. Using the emission equipment, the stove is changed step by step until performance is improved. In my opinion, the three most common mistakes in stoves are: 1) Mistaking mass for insulation; 2) Not optimizing heat transfer to the pot or griddle; and 3) Slowing the velocity of the hot gases. For greater detail see: http://www.pciaonline.org/design-principles. Just changing the shape of the combustion chamber can reduce emissions by a third. Changing the shape of the stove top can easily and significantly decrease fuel used to cook. Often these changes do not increase the cost of the stove.

Every year Aprovecho offers at least two week long training opportunities ("Stove Camps") in the Spring and Summer. We welcome researchers to live here and use the equipment to study stoves. Most years we do two to three trainings internationally with support from PCIA. Perhaps five or more stove developers come to the lab and tune up their stoves, as well.

Aprovecho helped to develop the Shell Foundation stove performance benchmarks in 2003 and the recent International Workshop Agreement (IWA) establishing a four tier system for fuel use, emissions, indoor emissions and safety. Moving stoves 'up the ladder' is why we do testing, providing measures of performance showing quantified improvement. Benchmarks and standards are a big help because useful comparisons can be made. Stoves get better when standards reveal the successful techniques that make truly improved and more effective stoves.

PCIA Training Opportunity: Assessing Stove Performance in the Field

Is your stove project ready to conduct the Controlled Cooking Test (CCT) or Kitchen Performance Test (KPT) to quantify the fuel use of your stove? The U.S. Environmental Protection Agency (USEPA), through contracts with Aprovecho Research Center and Berkeley Air Monitoring Group, will provide two Partner organizations support to conduct either the CCT or KPT to evaluate the field performance of their stove.

This current initiative builds on USEPA's evaluation of stove performance in the laboratory and previous field testing in Nepal, India, Peru, Rwanda, Laos and Bangladesh. You can learn more about these past efforts at **www.PCIAonline.org/proceedings**. The primary objective of this capacity building initiative is to assist Partner organizations to obtain field data on fuel use to inform and improve stove design, performance and use. In some cases, we will also assess emissions, including both health and climate-related pollutants.

This initiative consists of a stove testing workshop in which several local organizations will be invited to participate and a field study for the selected Partner organization. This is the first in a series of field stove performance testing opportunities. **The first round of CCT and KPT trainings/field studies will take place between June and August 2012.** We will advertise separately for future field stove testing to be conducted in fall 2012 and winter 2013.

For more information, including selection criteria and requirements, please visit the PCIA website at:
http://www.pciaonline.org/news/CCT-KPT-field-testing-announce

Colorado State University, Advanced Cookstove Laboratory

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The Advanced Cookstoves Laboratory at the Engines and Energy Conversion Laboratory (EECL) of Colorado State University has been working on the evaluation and improvement of biomass cookstoves for over a decade. In collaboration with partners such as Envirofit International, the laboratory has developed stoves which have reached over 40 countries and achieved total sales exceeding 300,000 units. The laboratory specializes in bringing rigorous, fundamental engineering and scientific practices to the design and evaluation of cookstoves. At any one time the lab employs 4-8 team members specifically dedicated to the cookstove program including technicians, research engineers, and graduate students.

The laboratory specializes in the testing of solid biomass fuel stoves including wood, charcoal, and agricultural waste but also has the capability of testing liquid fuels. The facility is arranged in order to accommodate stoves of all sizes, from small portable designs to built-in place configurations. To date, the laboratory has tested over 225 stove designs and conducted thousands of hours of performance testing. While the team typically focuses on laboratory testing, the team has also conducted field work in a number of different international locations in Latin America, Africa, and Asia.

A wide range of biomass stove related research is conducted at the EECL including thermal efficiency, emissions measurement, and stove durability and safety. The lab is equipped with three testing hoods; these systems are equipped with a wide range of analyzers and data collection systems and can also be configured for specialized measurements. The lab uses a Fourier Transform Infrared (FT-IR) and non-Dispersive Infrared (NDIR) spectrometers configured to measure the primary components of stoves emissions including carbon monoxide, carbon dioxide, and oxides of nitrogen as well as carcinogenic and toxic compounds such as formaldehyde, butadiene, and hydrogen cyanide. In addition to the spectrometer systems, the laboratory is equipped with a flame ionization analyzer capable of quantifying the hydrocarbons emitted during biomass combustion and a chemiluminescence analyzer for the measurement of oxides of nitrogen.

Particulate emissions from the stoves are quantified using gravimetric methods, including isokinetic sampling, in order to get the most accurate results possible. The facility is also capable of determining the ratio of organic to black carbon, a necessary component in evaluating the environmental impacts of a stove design, and is capable of determining the size distribution of particles emitted from a stove.

Photo: Dan Bihn

Colorado State University Advanced Cookstoves Laboratory

The EECL works with a number of different partners and organizations on a range of biomass and cookstove projects. These efforts range from fundamental research, the results of which are available in peer-review journals and conference publications, to stove development, third-party product evaluation and carbon program feasibility studies. When the lab is contracted by a third party to conduct research, testing results are the property of the funding organization and are available to the public at the discretion of that group. Testing plans and details are arranged on an individual basis with partners to ensure that the most accurate, appropriate, cost effective and informative data is being collected.

A number of important lessons have been learned at the lab over the years in regards to designing and testing biomass cookstoves. One of the most critical is the importance of having a robust testing system. The accuracy of results and amount of useful data which is gathered is directly related to the quality of the testing system used. Quality is not necessarily the same thing as cost; the most important thing is that the correct method is used for a given measurement and that the equipment is installed, calibrated, and used correctly. The most expensive equipment out there will give the wrong results if it isn't being used correctly by someone who understands the capabilities and limitations of that

system. The other critical element for a successful testing center is developing a quality testing plan. Biomass cookstoves are complex, variable devices. Great care needs to be taken to ensure that conditions are consistent between tests and that every test being conducted has a specific goal. How a test is conducted depends on the questions that experiment is trying to answer.

The Engines and Energy Conversion Laboratory is excited by the recent ISO International Workshop Agreement on Cookstoves work being conducted by PCIA and the Global Alliance and sees it as a great opportunity for testing centers from around the world to increase their collaborative efforts.

Testing Centers in Africa

CREEC'S STOVE TESTING SERVICE

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The Centre for Research in Energy and Energy Conservation (CREEC) is a not-for-profit organization for research, training and consultancy located at the College of Engineering, Design, Art and Technology (CEDAT) within Makerere University in Kampala, Uganda.

The centre focuses on four areas in renewable energy: bioenergy, solar PV, pico-hydro and energy management. CREEC's focus is on application and adaptation of technologies to the local and regional environment. Within bioenergy, the centre is currently active in improved cookstoves, biogas, gasification and briquette making. The organization is equipped with the Biomass Research Centre, a laboratory for conducting practical tests, training and applied research, which was built in 2008 in cooperation with GIZ.

The aim of the Biomass Research Centre is to develop into an independent and internationally recognized stove testing service using globally accepted testing procedures for the (East-) African region. The centre is equipped with a Portable Emission Monitoring System (PEMS) from Aprovecho Research Center, Particle and Temperature Sensors (PATS) from the University of California Berkeley, a Lascar Carbon Monoxide Sensor, weighing scales, stove use monitoring equipment, thermometers, etc. CREEC also has access to an oven to determine fuel moisture content and a bomb calorimeter. With this equipment, the testing centre is able to determine stove performance and support stove builders to design better stoves in the future.

Currently, CREEC employs four people in its stove testing service: two lab technicians, one lab assistant and a unit head.

Portable Emissions Monitoring System in the Biomass Research Centre

Stoves from within Uganda and other neighbouring countries like Rwanda, Kenya, Burundi and the Democratic Republic of Congo have been subjected to various lab tests at CREEC, such as the Water Boiling Test, the Controlled Cooking Test and the Iowa State Safety Test. Currently, CREEC is making arrangements to install a test kitchen for indoor air pollution measurements. Furthermore, the centre plans to introduce field testing and monitoring in the near future.

The stoves that have been tested and experimented with at the centre include a wide variety of fuels: wood, charcoal, other solid biomass, biogas and liquid fuels. Mud stoves and other rocket stoves, non-rocket stoves, gasifier stoves and solar cookers have also been tested. Due to facilities' limitations, institutional stoves have not yet been tested.

When carrying out these tests, the centre measures, calculates and analyses thermal efficiencies and stove emissions. Other aspects such as IAP concentrations,

safety and user acceptance are also looked at through protocols and surveys.

In principle CREEC works on an open-source basis, depending on confidentiality agreements with clients. Data collected is used to understand the stove performance and serves as a basis for recommendations on improvement of the stove design or is used in carbon finance programs. CREEC is currently looking into appropriate ways of publishing test results.

The centre's experience in stove testing reveals a number of significant challenges. First of all, stove manufacturers' stove design understanding and capacity are often insufficient. Secondly, the local manufacturing processes are not uniform. Thirdly, most stoves lack a power control to allow a simmering mode. The first two result in a high variance in quality and inconsistent stove dimensions within the same stove type. Another example is that producers copy other stove designs including the design flaws (such as lack of secondary air supply) since they have no understanding of how the stove works. CREEC continues to strengthen its training program to enhance knowledge transfer, build skills and increase the experience of stove manufacturers. These activities can take shape in general stove testing workshops or as tailor-made programs to suit the clients' specific requirements. With regard to stove testing itself, the centre recommends and implements in its protocols, testing of more than one sample of a particular stove type to provide statistically accurate data from which proper conclusions can be drawn.

CREEC is a core member of two working groups in the Global Alliance for Clean Cookstoves, namely "Technology and Fuels" and "Standards and Testing." Furthermore, starting from the inception of the Lima Consensus at the PCIA meeting in Peru (2011) through today, CREEC is actively involved in discussions (such as the ISO International Workshop on Clean and Efficient Cookstoves, which took place in February 2012) about the various tiers of stove performance. These International Workshop Agreement guidelines will form the basis of CREEC's stove testing service.

Organizations interested in having their stoves tested at CREEC's facilities are welcome to contact the centre through the following website www.creec.or.ug.

CREEC considers it a privilege to be partners with PCIA and the Alliance.

Stove training in the Biomass Research Centre

STOVE TESTING WEBINARS ON PCIA WEBSITE

Check out these stove testing related webinars available in full recordings and pdf format on the PCIA website!

EPA Lab Test Results for Household Cook Stoves—

Jim Jetter, U.S. EPA Senior Research Engineer, discusses lab test results for 22 cookstoves and 7 fuels conducted by the EPA using a variety of operating and testing conditions to test performance in terms of power usage, energy efficiency, fuel use and emissions.

Impacts of Household Fuel Consumption for Biomass Stove Programs in India, Nepal and Peru—

Michael Johnson of Berkeley Air Monitoring Group discusses KPT basics, gives an overview of field testing, presents results, provides ways to use the KPT results to enhance programmatic performance, and key recommendations for strengthening stove performance monitoring

Test Results of Cook Stove Performance—

Nordica MacCarty and Dean Still give an overview of the laboratory test methods and share the test results of 18 household cook stoves and fuels, including wood-burning stoves with and without chimneys, wood-burning stoves with electric fans, charcoal stoves, liquid-fuel stoves and a solar cooker. The testing evaluated fuel economy, emissions, safety & cost.

The University of Johannesburg SeTAR Centre Stove Testing Lab

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The Sustainable energy Technology and Research (SeTAR) Centre is a multi-disciplinary research facility based at the University of Johannesburg, South Africa. Established in March 2010 with assistance from GIZ, the mission of the Centre is to be a leader in the research and promotion of sustainable energy technologies in Southern African.

The Centre acts as an innovation hub for the development of pro-poor energy solutions that meet the needs of low income communities (i.e. cooking, heating, lighting, productive use). Uniquely for a facility of this type, it is housed within an academic institution ensuring a more permanent presence and the ability to draw on a wide pool of skills - essential considering the trans-disciplinary nature of energy poverty work. The team is comprised of University staff and research students and is led by Professor Harold Annegarn, Principal Investigator and Director of the Centre.

Central to our work is the SeTAR stove testing laboratory that is capable of characterising the thermal and emissions performance of a wide range of energy carriers and stove types. Customers to date include local government, NGOs and the private sector within South Africa, although we are now seeing a greater interest in our services from the rest of Africa as well as further afield. Internal research and development work is focused on local fuels and traditional devices such as the coal-burning *Mbaula*, a novel low emissions coal stove, safe paraffin stoves and pico-PV products. Complementing the SeTAR Lab is a team of field researchers who study energy access, socio-economics and the needs and aspirations of stove users. Their work informs laboratory testing, further enhances the innovation cycle and most importantly ensures that people's energy needs are satisfied.

Another key activity is the development of testing protocols that give an acceptable correlation between lab and field measurements. Our *Heterogeneous Testing Protocol* (HTP) is a novel carbon mass balance method which can evaluate stove system performance across any burn cycle.

This rigorous approach to stove analysis produces performance curves, useful for identifying optimal combustion conditions and any design related weaknesses. We have also developed what we call the Uncontrolled Cooking Test (UCT) – an enhanced low cost field-testing method that assesses the task-based system performance when cooking any meal under local conditions and user practice.

Only by observing the performance of a cooking system in real time can key safety and performance issues can be identified. The biggest lesson we've learned is to treat the stove, fuel, pot and cook as one system, the performance of which is dependent on multiple factors. Emissions can vary significantly with both pot size and power level. One kerosene (paraffin) stove designed to meet a high power CO/CO_2 certification test emitted far more CO at lower power because the turn-down was achieved by making the combustion grossly inefficient - this should have been avoided in the design phase.

Photo: M Ibraimo

Charcoal stove being lit in Nampula, Mozambique

On the more technical side, we've found that:

- Good performance is assured by keeping the excess air ratio under control while maintaining the correct balance of primary and secondary air.
- Common household practices should be taken into account when reporting laboratory test results. For example, if post-fire charcoal is typically disposed of rather than reused, then this 'lost' energy should be reported as part of performance results, preferably as two specific fuel consumption figures. Similarly, how you prepare and light a stove can significantly impact key metrics such as time to boil and particulate emissions, so the exact quantities and method used should be measured and reported with any test results.
- Most charcoal and alcohol stoves have too small a space between the burning fuel and the pot, resulting in poor combustion. A few HTP tests will

show the optimal configuration resulting in greatly reduced CO and PM emissions. However, for some stoves this gap is too large resulting in poor heat transfer.
- Undersized pot supports are also a common safety problem.

The SeTAR Centre took an active role at the recent ISO International Workshop on Cookstoves in the Netherlands. We are starting to present our results in line with the performance tiers, and look forward to conducting more background research on testing methods, equipment and global standards.

The SeTAR Lab provides stove testing work on a fee-for-service basis. Interested parties can contact us at setar@uj.ac.za. Prices depend on a variety of factors including the stove-fuel combination, the metrics and detail required and the number of replications. Our field survey team is available to conduct community-level stove use tests as well as in-depth social analysis.

Photo: J Robinson, UJ SeTAR Centre

3-stone wood fire, Nampula District, Mozambique

Testing Centers in Asia

GERES Biomass Energy Laboratory

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In 2009, GERES (Group for the Environment, Renewable Energy and Solidarity) established a biomass energy laboratory in Phnom Penh, Cambodia. This testing facility was set up in partnership with the Institute of Standards of Cambodia (ISC) and the Ministry of Industry, Mines and Energy (MIME).

The initial objectives were to improve the quality of the clay material used to make stoves, and to conduct biomass analysis for improved charcoal production. During 2010 this work was expanded to include emissions testing and improvements to stove performance. The measurement of indoor air pollution was incorporated into the laboratory's expanding workload at the beginning of 2011.

The lab technicians conduct testing in the laboratory and in the field directly with users in urban and rural areas. A total of five people are now employed at the laboratory, including one local counterpart from the ISC.

The laboratory's mission statement is: 'to accompany in the South East Asia region, national labs, stove producers, projects, aiming to largely disseminate cleaner and more efficient stoves with testing procedures linked to the field realities (stoves, materials, and fuels).'

Both wood and charcoal stoves are being tested. The laboratory is also pioneering the testing of improved 'green' charcoal and innovative char-briquettes, which use char residues from neighboring factories mixed with coconut shells carbonized in efficient T-LUD kilns for their raw materials. Services provided by the lab include comprehensive testing on efficiency, emissions and durability. In addition, thorough field testing provides accurate information on levels of user acceptance and levels of indoor air pollution exposure.

Photo: GERES

GERES Biomass Energy Laboratory, Cambodia

The lab utilizes the Portable Emissions Monitoring System (PEMS) and the Indoor Air Pollution meter from Aprovecho Research Center for stove performance and emissions testing. Other installed laboratory equipment includes precision scales, an oven and a muffle kiln. This equipment is used by GERES for a range of purposes including quality control of existing stove designs, design

improvements, development of new generation stoves, official certification on biomass (i.e. DIN EN 1860-2 – European standard for charcoal) and technical requirements for carbon financing.

To date the testing results have been mainly for internal purposes of GERES although some services have been provided to others organizations:

- Clay testing for RDI Cambodia implementing a water filter project
- Stove fuel consumption testing for Hydrologic (Cambodia) to access carbon finance on a water filter project
- Clay and stove testing for SNV Laos

In the near future, GERES will be exploring opportunities to enter into discussions with relevant stakeholders so that test results may be published and made available to a wider audience.

The critical importance of adapting laboratory testing procedures to practical usage within the local context is the primary lesson learned by GERES. Laboratory created improvements to stove performance and emissions can prove ineffective if feedback from field-based consultations on local user priorities and requirements are not incorporated at an early stage into the testing process.

Based on its extensive field experience, GERES has evolved a 'win-win' approach to its work with the stove supply chain. This includes training for producers, consultations with distributors and extensive field testing with users.

From GERES's experience, the most common performance pitfalls relate to insufficient priority given by laboratory-based testers to the reality experienced by daily field-based stove users. For example, important efforts to decrease emissions through lowering stove power can prove futile without taking into account that users will require a certain level of stove power for their cooking and time-related needs. Furthermore, users often have a very different method of operating a stove from that of a laboratory scientist. These differences can then have a significant impact on stove test results. Only a final field test can provide an accurate analysis of stove performance.

Photo: GERES

Wood stove testing at GERES Biomass Energy Laboratory, Cambodia

Despite having the technical capacity, GERES is currently not using the international Water Boiling Test for its internal testing. Instead, an adapted test was developed in order for it to be more representative of the Cambodian context. Plans are in place to begin work in 2012 with the Institute of Standards of Cambodia to incorporate this local protocol into the ISO standard and implement it on a national basis.

GERES is keen to share its technical expertise and work with partners with similar environmental and socio-economic development objectives. Priority will be given to relationships which would require a longer term and more broad-based support rather than one-off trainings. Plans are in place to launch a Global Stove Program to enable knowledge-sharing and the provision of technical services, including stove testing and development. Prices would vary according to the tailor-made solutions required.

For more information visit the website http://www.cambodia.geres.eu or contact David Beritault at d.beritault@geres.eu

China Agricultural University Testing Center for Household Biomass Stoves

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Background

The testing center for household biomass stoves, located at Shangzhuang Field Station of China Agricultural University, was established in 2010. The testing center belongs to the BioEnergy Engineering and Low Carbon Technology Laboratory, and occupies an area of more than 200 square meters (over 2100 ft^2). It is committed to establishing optimized methodologies for the performance assessment of stoves globally, as well as promoting the development of the stove industry in China. The testing center is working on developing techniques and standardized systems for biomass cookstoves from different aspects, including combustion theory, gas emissions, fuel properties, stove performance test results and so on. Currently, the testing center is an important department of the Key Laboratory of Clean Production and Utilization of Renewable Energy, Ministry of Agriculture, P. R. China (CPURE).

Photo: Gao Bo

Shanxi Jinqilin improved biomass stove at the CAU testing center

Exchange and cooperation

The testing center has established tight connections with leading biomass stove producers, testing centers, and research institutes in China and abroad. Some major partners include: China Association of Rural Energy Industry (CAREI); Aprovecho Research Center (see article on page 3); Colorado State University (see article on page 5); University of Illinois, Urbana-Champaign; Partnership for Clean Indoor Air (PCIA); and the Global Alliance for Clean Cookstoves (the Alliance).

Facilities

The testing center analyzes biomass cookstove performance and assesses product quality independently. Biomass-saving cookstoves and semi-gasified biomass cookstoves using agricultural waste, wood, and pellets have been tested since 2010. The major indicators of evaluation include thermal performance, emission performance, indoor air pollution concentrations, durability, safety, operational performance, and customer comments/user acceptance.

The testing center's Gas Emissions Monitoring System can perform continuous analysis on the concentration of different substances, such as CO, CO2, HC, NO, NO2, SO2, PM2.5, PM10, and TSP (Total Suspended Particulate matter). Currently, the center has two PhD supervisors and several graduate students. The table below shows the various indicators, parameters, standards and instruments used to evaluate biomass cookstoves.

Table 1 Evaluation indicators and standards

Evaluation indicators	Testing parameter	Standards
Thermal performance	Thermal efficiency	GB6412-86/ NY-T8-06/WBT4.1.2
Emission performance	CO, CO_2, HC, NO, NO_2, SO_2, TSP	GB16157-96/DB11T540-08
Indoor air pollutant concentration	CO, $PM_{2.5}$, PM_{10}	GBT18883-02/GB3095-96

Table 2 Instruments for thermal performance determination

Name	Model	Precision
Elemental analyzer	Elementar VARIO III	≤0.3% abs (0.05g diazotate)
Oxygen bomb calorimeter	ZDHW-A5	0.0001k
Mini Plant crusher	TT30-FZ-102	Crushing effect 120 mesh, Screen hole diameter 0.5 mm
Analytical balance	FA2104N	0.001g
Electronic balance	SL6001	0.1g
Thermocouple thermometer	TES-1315K	0.1˚C
Anemometer	Fluke 925	0.01m/s
Mercurial thermometer		0.02
Air drying oven	GZX-9140 MBE	
Xox resistance furance	SX2-8-10	

Table 3 Instruments for emission performance and indoor air quality

Name	Model	Precision
Portable Emissions Monitoring System	PEMS 2011	CO: 0.2ppm; CO_2: 0.1 ppm; PM: 20 μg/m^3.
Indoor Air Pollution Meter	IAPM 1343 & 1344	CO: 0.2 ppm; PM: 20 μg/m^3.
End-gas-analyzer	IPEXD	CO: 0.01%; CO_2: 0.1%; HC: 1 ppm; O_2: 0.01%; NO: 1 ppm.
Lascar CO Logger	EC-USB-CO	CO: 0-0.01%
SKC Pump	224-44 XR	
Nephelometer	M 903	

Photos: Gao Bo

Equipment at the PEMS Control Panel and Indoor Air Pollution Meter at the CAU Testing Center for Household Biomass Stoves

Research results

The results of recent testing of a semi-gasified biomass cookstove indicated that the peak of CO emissions appeared at ignition and flameout points. The concentration of CO_2 and O_2 in the smoke showed a negative correlation (R^2>0.9). The concentration of NO_x showed a negative correlation with smoke temperature (R^2>0.8). These results are about to be used to make design improvements. The results also indicated that the current stoves are generating lower emissions than former models.

Photo: Ding Hongyan

Stove Performance Monitoring System

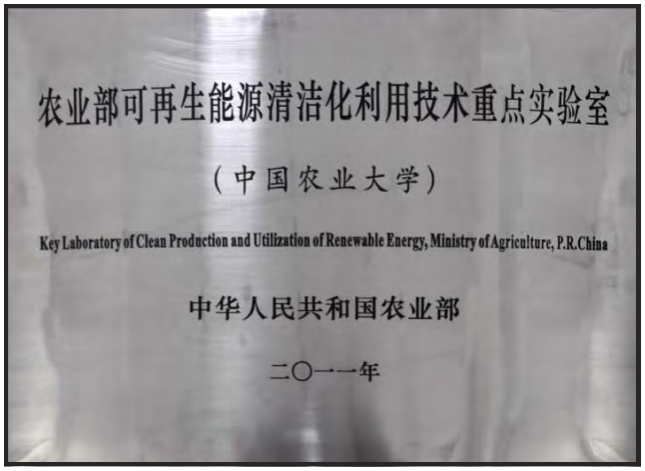
Major testing protocols for biomass cookstoves (including WBT 4.1.2, USA) in China and abroad have been compared and analyzed. The results indicated that the terminal point of testing, amount of water, and fuel type showed great influence on the results of thermal efficiency.

Paper publications:

Results from the testing center have been published and can be accessed in the following professional publications:

1. Wei Xiaoming, Wei Quanyuan, Wei Xiuying, Xiao Junhua, Cheng Xiaofu,.Dong Renjie. Influence on indoor air quality by using different type of stove and fuel. Transactions of the Chinese Society of Agricultural Engineering, 2006, 22 (si1): 236-239, in Chinese.
2. Du Liying, Wei Quanyuan, Wei Xiuying, Xiao Junhua, Chen Xiaofu, Dong Renjie. Impact of construction and ventilation on indoor air quality. Transactions of the Chinese Society of Agricultural Engineering, 2006, 22 (si1): 240-242, in Chinese.
3. Guo Jianbin, Wei Quanyuan, Wei Xiuying, Xiao Junhua, Chen Xiaofu, Dong Renjie. Relativity analysis of countryside indoor air pollution. Transactions of the Chinese Society of Agricultural Engineering, 2006, 22 (si1): 243-247, in Chinese.
4. Li Xiang, Wei Quanyuan, Wei Xiuying, Xiao Junhua, Chen Xiaofu, Dong Renjie. Casus analysis of rural indoor air quality. Transactions of the Chinese Society of Agricultural Engineering, 2006, 22 (si1): 231-235, in Chinese.
5. Weng Xuanwei. Study on performance and generalize impact factors of high efficiency low emissions biomass stove of North China. Master's degree thesis, China Agricultural University, 2008, in Chinese.
6. Gao Bo, Huang Shao-jiong, Liu Jia-xin, Su Cun-gang, Dong Ren-jie, Pang Chang-le. Study on the test method of heat efficiency of household biomass stove. Renewable Energy Resources, 2011, 29 (3): 96-99, in Chinese.
7. Changle Pang, Li Chen, Renjie Dong. New Type of Distributed Biomass Combustion Devices Necessity and Feasibility in China. Advanced Materials Research. 2012, (383-390): 4013-4016.

The testing center is expecting exchange and cooperation with PCIA Partners. We would like to make our contribution to the development of biomass stoves around the world.



Testing Centers in Latin America

THE STOVE TESTING CENTER IN BOLIVIA

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The mission of the Stove Testing Center (STC) in Bolivia is to offer a high quality service to project developers, stove entrepreneurs, research institutions and the general public to improve the performance of the stoves by supporting technology development with internationally recognized stove testing procedures and equipment.

The implementation of the center (April 2007), involved the efforts of our local GIZ team, the Universities of San Simon (UMSS, Cochabamba) and San Andrés (UMSA, La Paz), Delft University, and Nordica MacCarty from Aprovecho Research Center. After the initial testing center setup, very important alliances were made with other PCIA Partners and the Environmental Protection Agency (EPA) laboratory for developing the STC activities, improving the application of protocols, and training our team in charge.

Photo: En Dev—Bolivia/GIZ

GIZ Stove Testing Center in Bolivia

Throughout 3 years of work, the STC- Bolivia has completed approximately 300 tests on more than 20 different stove models all around Bolivia and Peru. The STC currently has a senior researcher and two research assistants who have knowledge and work experience in field and laboratory testing, and who are supported by specialized technicians from the GIZ EnDev project.

Traditional stoves, solar stoves, improved stoves with and without chimney and/or ceramic combustion chambers, clay and metallic stoves have been tested. Fuels used in the testing are wood, cow dung, llama dung and grass mats.

Tests are conducted in the laboratory as well as in the field; most to date have been Water Boiling Tests (WBT). About 15% have been Controlled Cooking Tests (CCT) in the field. Complementary, safety and emissions testing are part of the lab's routine testing as well.

Currently, our performance indicators in lab and field testing include:

- Energy consumption to complete WBT;
- Time to boil 5 liters of water;
- Indoor Air Pollution (IAP) concentrations (PM 2.5 and CO) (relative to three-stone fire); and
- Safety.

One of the goals we had last year was to conduct a KPT study in a valley region of Bolivia. With the objective of getting Malena stove efficiency results in field conditions, the EnDev team trained by Berkeley Air Monitoring Group in Lima in 2010, developed a KPT study with 75 families in two phases (traditional stove and Malena Stove). The results of this study will be published in the coming months.

For the WBT we have all the required equipment including a temperature data acquisition system (DAQ) for more precise control of fuel use, especially for simmer phase. In the case of emissions testing, we have implemented a mixing chamber for more representative air sampling during the test, and are using IAP meters (from Aprovecho Research Center) for real-time measurement of PM-2.5 and CO concentrations. Additionally, we use routine equipment like humidity meters, CO meters for air exchange rate studies, balances for fuel use and others.

Photo: En Dev—Bolivia/GIZ

GIZ Bolivia Stove Testing Center team during routine testing

Having a testing center has allowed us to significantly improve overall stove performance and choose acceptable stove models. The laboratory results are complemented by field observation and interviews that better show the acceptance and use of the new models. The STC has also figured out the impact on performance of different materials or building processes and changes in the design. Most important is the possibility of testing new developments and modifications for the different types of fuel and for the diverse geographic, social and cultural scenarios in Bolivia to give them official certification.

Our experience has taught us that it is important to test stove models before they are financed and especially before they are disseminated and used by the families. It is necessary to have a budget for testing activities (time, trained staff, and field schedules). Changes in stove parts, designs and models can be made in a more practical and efficient way if they are supported by tests to measure the effects of these adjustments.

In addition to routine testing, it is very important to plan research activities related to adapting and improving the international protocols to local conditions (altitude, local fuels, climatology, local materials, etc.). Moreover, STCs must work to approve official local regulations and standards for testing protocols.

The three most common challenges in stove testing are: 1) Use of local fuels that do not have calorimetric data to calculate valid energy consumption; 2) Difficult conversion between concentration and emission values and 3) Lack of training in the use of statistical tools for analyzing test data.

The first case can be improved analyzing the typical fuels with calorimetric bombs. This analysis is really only needed once using representative samples of local fuels. For the second case, a mathematical "box model" can be used to convert between concentration and emission values, but caution is advised because the model includes the following assumptions: the air exchange rate is accurately measured and constant, emissions are completely mixed in room air, and the emission rate is constant. The model may be used when test conditions are consistent with the model assumptions . Finally, for all data obtained during testing, it is necessary to use statistical tools to analyze and report results. In this case, specific training and/or review of literature can be a solution.

The STC has already given support to GIZ Peru, and continuously provides support to other stove projects in Bolivia. Additionally, it would be a great pleasure for us to share information and protocols in Spanish and provide counseling to PCIA projects that request them. Any Partners who are interested can please contact us with a post on our web site at http://www.stovesbolivia.wordpress.com.

Photo: En Dev—Bolivia/GIZ

Malena Stove in Bolivia

Any kind of stove can be tested in our facilities including solar stoves. We mainly need data related to the stove's designed range of operations and any specific requirements for testing. It is important to note that the Bolivian STC is geographically located in demanding conditions for more realistic combustion performance (3600 meters above sea level). This ensures that the stove will be tested under the most demanding energy efficiency and emission conditions. We are available to work with Partners to improve designs, analyze performance data, and test stoves under international protocols and training.

Currently we are working to improve our protocols to satisfy the new units of performance measures incorporated into the ISO International Workshop Agreement tiers. For example, we are working on converting IAP concentrations to emissions using a box-model and air exchange rate studies. In the same way, we need to explore the protocols for a better control of High Power and Low Power thermal efficiency tests. Related to this, we are analyzing what is needed to improve our equipment and, of course, we are looking for funds to finance this improvement. This last point will be very important.

Zamorano Improved Stove Certification Center (ISCC)

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Zamorano University is located thirty kilometers southeast of Tegucigalpa, Honduras and has over 1,200 students enrolled from over 20 countries from throughout Latin America. Zamorano is a one-of-a-kind university, providing young people with more than a quality academic formation obtained from theory taught by experienced teachers in the classroom. The University has an advantage that other universities do not – the Learning-by-Doing philosophy. Students participate in the field in primary agricultural and natural resource production, agroindustrial transformation and commercialization/marketing with the support of modern analytical research and new product development laboratories. A valuable part of this infrastructure is the Improved Stove Certification Center.

Zamorano Improved Stove Certification Center, Honduras

Established in 2009 with the help of funding from the TPW Energy Collaborative, the Zamorano Improved Stove Certification Center's (ISCC) mission is to "Provide information so that Governments, NGOs, donors and users can select the best stove model option given their specific objectives and social/environmental conditions". The laboratory design, with six identical kitchens, allows the comparable evaluation of overall emissions, exposure, fuel efficiency, and social compatibility and provides an excellent environment for teaching Zamorano students and providing workshops to interested parties. To date, over 15 different types of improved stoves have been tested in the laboratory and our location in the middle of Central America allows cost efficient field evaluation utilizing internationally recognized protocols. Zamorano University is a private, non-for-profit university and is not directly financed by any governmental agencies or NGOs, allowing complete impartiality during the implementation of evaluation activities.

In addition to the evaluation of multiple rocket stove designs, TLUD combustion chambers are being evaluated for their applicability to the "Plancha" (griddle) stove design, which is common throughout most of the region. Different types of fuels including pine, carbon and oak have been tested and agricultural waste briquette designs are being evaluated for efficiency and emissions utilizing various combustion chambers.

The Zamorano stove center lab is equipped with a Portable Emissions Monitoring System (PEMS) and an Indoor Air Pollution Meter, which can either be installed in the test kitchens or transported to the field for real-use measurements of emissions, exposure and efficiency. Currently much of the work is contracted by individual organizations so test results are not made public due to client confidentiality. Testing for ISO certification will allow these results to be available to all interested parties.

PEMS installed in a rural household to evaluate emissions during real use.

Typically, clients determine the types of evaluations needed based on their specific objectives, which can include documenting to past and potential donors the impact of the improved stove project implementation, new stove design improvement, carbon credits and

quality control of technicians who are installing stoves. Because results are provided as separate categories in the detailed reports, clients can see if their desired results of improving health conditions, reduction of fuel consumption, and thus forest degradation, or the reduction of greenhouse gasses are being met. The Water Boiling Test, the Controlled Cooking Test and the Kitchen Performance Test are the protocols used to evaluate improved stoves.

Although many laboratories and universities in developed countries dedicate valuable efforts in design specifications and the resulting effects on emissions and efficiency, less work has been completed in identifying the social and environmental contexts which can help insure successful stove usage. The importance of conducting a thorough socioeconomic assessment including the specific cultural, social, dietary, economic and environmental components needs to be identified before installing an improved stove to a specific region. Improved stoves might have the best performance regarding emissions and fuel efficiency, but if the stoves don't meet the social and environmental habits of the region, the stove project will ultimately not be successful. The Zamorano ISCC is uniquely positioned to address this information need and provide field evaluations to facilitate this type of research in our kitchen facilities.

Interestingly, during Kitchen Performance Tests conducted in local communities, the reduction in fuel use was not as high as expected. This is largely due to the increased use of the improved stove. Households continue to dedicate equivalent time collecting firewood but with the surplus left after cooking requirements are met, the improved stoves are then used for boiling water for consumption, sterilizing baby bottles, or cooking additional food (such as tortillas) for sale. Thus, although the initial objective of reducing fuel consumption was not completely met, the overall impact on the household health and economics was remarkable.

PCIA Partners and other organizations and individuals may send and/or install their stoves at the ISCC facility for evaluation. The specific objective of the evaluation must be identified to allow the appropriate protocol to be selected as well as the sample size. The Zamorano ISCC works closely with our clients during this process to help ensure that the appropriate information is collected in a way that is optimally useful for the needs of the organization.

The ISCC has conducted multiple workshops on the rocket improved stoves design principles, stove construction and evaluation protocols. To date, ISCC workshops have been conducted in Santa Barbara, Copan and Ceiba in Honduras as well as in Totonicapán, Guatemala. Regional workshops have been held in the ISCC lab for energy specialists from Haiti World Bank Institute, Peace Corps (Latin America Regional representatives, Honduras and Nicaragua), Stove Team International's Rotary members from Oregon and the Honduran military. "Stove Camps" in Spanish have been held on the past two years about improved stove design principles and micro-gasification with participants from throughout the region. Over 170 individuals have participated in training activities in the ISCC in addition to over 300 Zamorano students that are involved in the Learning-by Doing education every year in the laboratory facilities.

Zamorano students constructing a rocket stove during their Learning-by-Doing activities

As a regional testing center Zamorano will use the framework of the ISO International Workshop Agreement to help develop new protocols to evaluate "plancha" stoves by using a three stone fire with a metal plate/ griddle/plancha as the baseline for emissions and efficiency. Additionally, we believe that pot shape and size specifications should be modified to help insure that heat transfer is more realistically measured for the Central American context. By achieving this, there will be better criteria to compare improved stoves that are commonly used in the region.

SENCICO — Peruvian Government Stove Testing Laboratory

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The stove testing laboratory at SENCICO began operations in late 2009, after the promulgation of DS 015-2009-HOUSING, which designates SENCICO responsible for the evaluation and certification of cookstoves. The decree provides that people and companies who have developed improved stoves should obtain, prior to use anywhere in the country, the Certificate of Validation of their stove model, given by SENCICO.

In compliance with the decree, SENCICO implemented a Regulation on Assessment and Certification of Cookstoves, which establishes the administrative procedures, assessment protocols for laboratory testing, and guidelines for the interpretation of the test results.

In developing the regulation, SENCICO formed a committee with representatives from public and private institutions related to the topic including: The Ministry of Housing, Construction and Sanitation, The Ministry of Energy and Mines, the World Health Organization and Pan American Health Organization, The German Development Cooperation (GIZ), Catholic University of Peru, Microsol, Instituto Trabajo y Familia /Sembrando and SENCICO.

The improved cookstoves lab has been built with SENCICO's own resources at its headquarters in Los Olivos, and equipped with testing instruments donated by Project EnDev - GIZ. It has two technicians responsible for implementing the tests, and an adviser from GIZ. Management Research and Standardization of SENCICO, participates in the coordination and supervision.

The project EnDev - GIZ funded a training workshop for the evaluation of improved cookstoves, by specialists from the Aprovecho Research Center.

In the laboratory, 24 models of improved stoves have been assessed and certified that use firewood for family use, usually with two burners and that allow the placement of partially submerged pots. Three burner improved stoves have also been evaluated and, less regularly, one burner stoves. We have evaluated models of built-in-place stoves, as well as portable models. The models tested are applicable in all regions. There have been models with combustion chambers of adobe or masonry clay brick walls and floor covered with insulating mixtures, as well as ceramic chambers.

Testing improved stoves at SENCICO

Some models include a "fish spine", which aims to concentrate fire on the first burner and drive the smoke into the chimney. Some models also include an ash tray in the bottom of the stove. Ash can fall through a rack or metal grate and collect in the tray for periodic ash removal. Stove models usually have a metal chimney, but some models have cement or clay chimneys. We have evaluated stove models that burn dung, and the results are in the validation stage. The lab has developed proposed assessment protocols for dung stoves and field verification.

Assessment begins with a preliminary test, from which adjustments are made, allowing for improved efficiency. The evaluation is focused on three aspects: concentration of pollutants, efficiency and safety of the stove. The standards that we use in the SENCICO lab are:

- CO concentration maximum 15% of that obtained in similar test in cooking over an open fire.
- PM 2.5 Concentration - Maximum 15% of that obtained in similar test in cooking over an open fire.
- Energy consumption per liter of water - Maximum 6MJ/liter.
- Maximum time - 35 minutes to boil.

The lab is equipped with indoor air pollution meters, thermometers, scales, moisture meters and accessories.

The results of PM 2.5 concentration tests achieve, on average, values less than 4% the concentration produced by a traditional three-stone fire. The CO concentration results reach values below 2%. In water boiling tests, registered cooking times were between 15 and 35 minutes. The energy consumption of the certified improved stoves reaches values lower than 6MJ/liter.

The results of the evaluation tests are presented in the Certificate of Validation for the proponent. In the lab showroom, we have posted the results of the assessments for each model evaluated.

Improved stove showroom at the SENCICO lab

In our experience:

- The chimney must be light (and metal should be protected to prevent burns); masonry chimneys, if not properly secured to the wall of the house, may fail due to seismic events. The built-in-place stoves commonly used in Peru are more stable than portable stoves.
- An improved stove must have two burners to meet the need of Peruvian families.
- The best values for efficiency have been achieved with reducing the size of the cooking chamber, but efficiency depends on more than the volume of the chamber.
- It is important that the model has a grate for positioning the wood, which allows aeration of combustion chamber and ash removal

Interested parties should submit a request to SENCICO attaching the technical file of the stove model they want to evaluate and a copy of payment receipt for the certification. Two rates have been established: S/.1892 (US $698) with metal chimney and S/.2980 (US $1099) with masonry fireplace.

Establishing cooperation agreements, such as the one between SENCICO and Project EnDev / GIZ, which enable specific studies as part of share common interest, are important.

SENCICO Improved Stove Testing Lab

We plan to:

- Update protocols with the recommendations from the ISO international workshop;
- Manage implementation suitable for laboratory environments;
- Strengthen the capacity of technical staff through the exchange of experiences with experts from other laboratories;
- Request approval of the assessment protocols for dung stoves and field evaluation; and
- Develop field studies and share the results with PCIA Partners.

CALL FOR DURABILITY PROTOCOLS

In addition to Colorado State University (see article on next page) we know many other organizations conduct durability testing. For example, during the recent PCIA regional study tour in Guatemala, we saw the durability testing HELPS International conducts in the lab and field to identify design weaknesses and test new materials. We are interested in learning more about your durability testing and exploring durability testing in an upcoming webinar.

If you have experience in this area to share, please send us the following information: name, organization, description of your durability testing and the protocol you use, what you have learned from durability testing, and any recommendations you have for others interested in conducting durability testing to moderator@pciaonline.org

SPOTLIGHT ON DURABILITY TESTING

Durability Testing

Christian L'Orange, clorange@engr.colostate.edu
Morgan DeFoort, morgan.defoort@colostate.edu

While great strides have been made in the stove sector in recent years, robust methods of evaluating stove durability and product life are still needed. There are few products which present more of a challenge in terms of durability than biomass cookstoves. Stoves are often used for thousands of hours a year. They are used with a wide range of fuels which often contain ash which is highly corrosive at high temperatures. Stoves are left outside in the rain. They are moved by boat, truck, and donkey. On top of all that you add in the users. They walk away from it and a cooking pot boils over. They over feed it and the front of the stove burns. They use fuels the stove was never designed to burn. All of this leads to a product which needs to be able to withstand unbelievable wear-and-tear and still be at a price point people can afford.

The Advanced Cookstoves Laboratory at the Engines and Energy Conversion Laboratory (EECL) of Colorado State University has been actively looking at stove durability for a number of years and while great strides have been made, much work still needs to occur. The laboratory has been developing a standard durability protocol to identify early failure modes, these findings can be incorporated into the design process in order to begin designing better stoves.

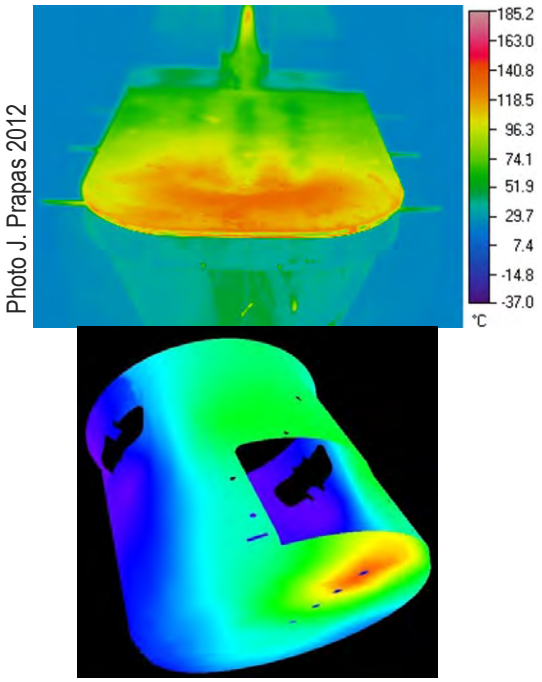


Figure 1: Surface Temperature Contours [above] thermal imaging; [below] point surface measurements superimposed on 3D model

Tests included in the durability protocol include spatial surface temperature measurements to identify material and surface coating temperature requirements (see Figure 1 below), corrosion testing to inform material selection (see Figure 2 below), and mechanical testing to identify weakness in stove design. As with any testing protocol it is important to recognize what a test does and does not tell you. The majority of the tests currently included in the EECL Stove Durability Protocol can identify early failure modes and weak points of a stove design; what the protocol is not currently capable of is predicting failure modes which will occur after multiple years of use or at identifying when a failure will occur.

In order to help answer these time dependent durability issues, the EECL worked with Envirofit International to help establish a 24/7 stove testing facility outside of Bangalore, India. At the facility, stoves are cycled 24 hours a day, 7 days a week looking to identify weaknesses in stove design and construction and to begin the process of predicting realistic stove life. While the Envirofit International durability lab provides invaluable information much work still needs to be done by the international stoves community in the development of stove durability protocols. Accelerated testing protocols and methods are needed so that stove durability can be more proactively incorporated into the design and development process and to develop laboratory tests which more closely replicate the conditions under which stoves are used.

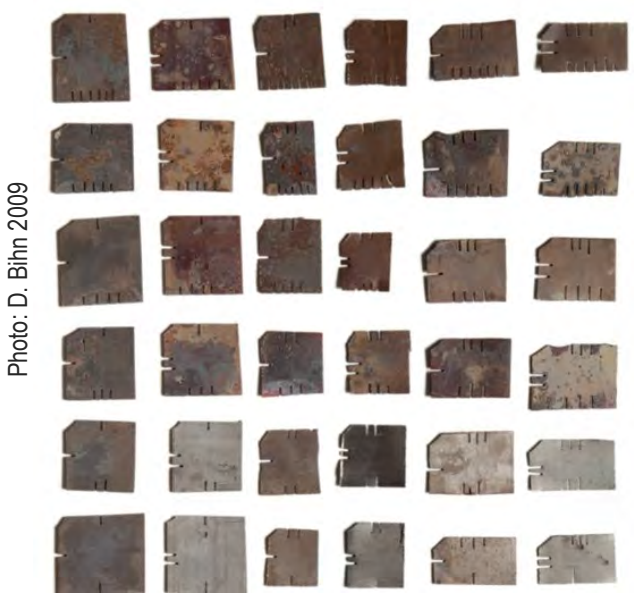


Figure 2: Material Corrosion Testing Samples

USEPA Selects Stoves for 3rd Round of Stove Performance Testing

The U.S. Environmental Protection Agency (USEPA) is excited to announce the selection of 20 cooking technologies for our third round of laboratory stove performance testing. We received more than twice as many applications in response to our open solicitation last fall than we are able to test. You can view the announcement and selection criteria at http://www.pciaonline.org/content/applications-usepa-stove-testing

We will be testing a wide range of cooking technologies and fuels being promoted in countries in Africa, Asia and Latin America, including institutional, built-in-place griddle, TLUD, fan, charcoal, kerosene, solar, and LPG stoves (see list below or on website). Each stove will be tested under a variety of operating and testing conditions for fuel consumption, energy efficiency, power, and emissions.

Results from the testing will be published in the peer-reviewed scientific literature and will be distributed through PCIA communication channels. You can see the published results of the previous two rounds of stove testing on the PCIA website **Research** and **Proceedings** pages.

The goals of USEPA's stove performance testing are to:

1. Provide partners with independent, performance evaluations of cookstoves under controlled, laboratory test conditions that are useful for informing and improving design, and selecting stoves for field trials;
2. Provide health researchers and climate scientists with test results on emissions that affect human health and the global climate;
3. Perform experiments to inform the process of developing improved test methods; and
4. Transfer knowledge to build capacity in other countries for evaluating cookstoves.

List of selected stoves:

- Aprovecho Research Center, 60 Liter institutional stove
- Biolite, Homestove
- Butterfly, Model 2412 kerosene pressure stove
- Butterfly, Model 2668 Kerosene wick stove
- CREEC, Mwoto TLUD
- EcoZoom, Second Wind charcoal
- Envirofit International, CH-4400
- Fuego del Sol, Global Sun Oven
- GIRA, A.C., Patsari
- Miombo, Peko Pe TLUD
- New Dawn Engineering, Vesto
- Parabolic solar cooker
- Prakti Design Labs, charcoal stove
- Prakti Design Labs, institutional stove
- Project Gaia, CleanCook Stove
- Solar Household Energy, HotPot
- Solgas/Repsol, LPG stove
- Stove Team International, Ecocina
- The Paradigm Project, Jiko Poa
- Turbococina

We will share the results of our 3rd round of laboratory stove testing in a future webinar.

IN CASE YOU MISSED IT….

PCIA Bulletin — Special Edition, LA/C Study Tour!

The Partnership for Clean Indoor Air (PCIA) recently sponsored an exciting new technical capacity-building initiative for 18 Partner organizations, based in 9 countries, serving Latin America and the Caribbean. During a 3-day study tour in Guatemala, February 6 - 8, 2012, these organizations experienced firsthand how **HELPS International** has developed successful manufacturing, distribution and marketing approaches to scale up their improved cook stove program. This special edition Bulletin provides highlights from the three days of factory and community visits, and in-depth discussions that took place.

To find out more, go to the PCIA website Bulletin page: **http://www.pciaonline.org/bulletin**

IWA PROCEEDINGS AVAILABLE ON THE PCIA WEBSITE

An International Standards Organization (ISO) International Workshop Agreement (IWA) was finalized and unanimously affirmed by more than 90 stakeholders present at the ISO International Workshop on Cookstoves February 28 – 29, 2012 in The Hague, Netherlands.

The IWA provides guidance for rating cook stoves on four key performance indicators: fuel use/efficiency, total emissions, indoor emissions, and safety.

The agenda, full workshop proceedings, and a draft of the IWA are all posted on the PCIA website at: **www.pciaonline.org/proceedings/iso-international-workshop-clean-and-efficient-cookstoves.** Read the full announcement about the IWA process and achievements at **http://www.pciaonline.org/news/cookstoves-iwa-unanimously-approved**

The Alliance Commitment to International Standards and Testing

One of the goals of the Global Alliance for Clean Cookstoves (Alliance) is to foster an enabling environment for a thriving clean cookstoves and fuels market through the development of appropriate structural conditions that are critical for advancing the sector. Building such a framework however, often entails a range of activities that can be prohibitively expensive for any one stakeholder to undertake, and are best suited for a collaborate process involving a variety of stakeholders and skills.

One area of common engagement that is a priority for the Alliance is the promotion of international standards and rigorous testing protocols because this is one of the most cost-effective measures that can be taken to advance the development of a thriving global market for clean cookstoves and fuels.

The recent ISO International Workshop Agreement (IWA) that was negotiated at a recent stakeholders meeting in the Netherlands is a significant step forward in the efforts to scale up clean cookstove and fuels as the draft agreement provides guidance for rating stoves. The Alliance is committed to disseminating the results of the IWA, strengthening existing protocols and the network of regional testing centers, and developing a process for evaluating existing protocols and developing new ones to assess locally produced stoves.

The Alliance is working to advance high priority research and testing initiatives that include mapping the results of each commonly used protocol, assessing and improving current protocols, capacity building for regional testing centers, and integrating lab and field testing. The Alliance is in the process of hiring a Program Manager for Standards and Testing and will soon issue a Request for Proposals on how best to strengthen the capacity, equipment and global network of national and regional testing centers. For more information contact: info@cleancookstoves.org.

RECENT PARTNER ACTIVITY

10,000 Improved Cookstoves – EcoZoom conducts a pilot project in Mexico with new plancha stove

Design – Training – Distribution – Installation. *Project Mexico* was the first initiative where EcoZoom got to be involved in all aspects of getting a stove from lab to factory to cook. EcoZoom's core business is to focus on providing the right products for cooks, but it was an amazing experience to complete trainings and installations in country. Videos on different parts of the project are available at www.ecozoom.com, and the PCIA website at http://www.pciaonline.org/view/gallery.

The EcoZoom "La Mera Mera" plancha stove was designed to be safer, more efficient, and faster than traditional stoves. EcoZoom traveled around Mexico to conduct trainings with over 90 stove installers - who received materials and are now able to train others. EcoZoom travelled with new trainers back to their municipalities and participated in the first day or two of installations to see how effective the training was, correct any loose ends and see reactions from cooks first hand.

The 10,000 stoves were well received and they're planning to expand this project in 2012. EcoZoom is already getting follow on requests in pilot states as well as new orders in several other states. Over 6 million families in Mexico need a stove so they've got their work cut out for them!

LA MERA MERA IN ACTION

PCIA Supported Improved Stove Training in Malawi

The United Nations' has designated 2012 as the International Year of Sustainable Energy for All. As part of promoting sustainable energy for all in Malawi, forty-seven participants from twenty-one organizations joined a team of five biomass energy professionals from Germany, Malawi, South Africa and Uganda in an improved stove training workshop held in Lilongwe from the 20th to 23rd March, 2012. The event was organized by Developing Innovative Solutions with Communities to Overcome Vulnerability through Enhanced Resilience (DISCOVER) Project with support from the Partnership for Clean Indoor Air (PCIA).

The workshop focused on technical as well as social criteria for stove selection and adoption so that stoves that are disseminated are continually used in households. Participants and invitees included stove producers and builders, project implementers, field officers, representatives of organizations with an environmental focus, and representatives of government agencies. The participants practiced how to conduct Controlled Cooking Tests (CCTs), Water Boiling Tests (WBTs) and safety tests, and learned about Kitchen Performance Tests (KPTs). In addition, many representatives expressed specific interest in learning about the various models of improved cook stoves (ICS) being promoted in Malawi, how to produce stoves, how to create partnerships with other organizations to promote ICS, learning about strategies used to promote stove adoption, challenges faced in stove promotion, and advocacy needs of the sector.

Workshop participants conducting stove testing

During the first three days of the workshop, participants worked with members of PCIA's international team of biomass energy professionals to gain a deeper understanding on biomass energy and specifically on how to test the efficiency of improved cook stoves and

the importance of quality control and standardization. The final day was an open-day for a wider audience including decision makers of government and civil society organizations to share learning and promote collaboration. During this four day event, presentations and discussions went far beyond stove testing and covered a wide range of topics relevant to cookstove producers, implementers and the communities they work in and with – and highlighted issues such as the links between improved cookstoves and other sectors (health, nutrition, food security, energy and environment), with specific emphasis on the role of improved cookstoves and effective ventilation in reducing indoor air pollution; other topics covered were stove production costs and pricing; stove testing; and the importance of quality control, standards and monitoring.

EVENTS AND ANNOUNCEMENTS

"Air That We Breathe", The Fifth National Symposium on Air Resource Management, May 11, 2012, Colombo, Sri Lanka

The symposium will be a forum to present and discuss the most recent technological, scientific and policy developments associated with air pollution problems in front of an audience of eminent Researchers, Scientists, Policy makers and other Professionals. It is being organized by Air Resource Management Centre (AirMAC) of Ministry of Environment and Clean Air Sri Lanka.

The objective of the symposium is to integrate the views of technocrats, scientists and other professionals from a number of state and private institutions in the country, involved in air quality research, development and implementation activities for better tomorrow.

The one day symposium will include three technical sessions which broadly cover the following areas: Air pollution and public health; Indoor air pollution; Air Monitoring, modelling and emission inventory; Policies and economics of air pollution; Vehicular air pollution; and Point and non-point source air pollution control.

For more information, please contact airmac@sltnet.lk

Asia Clean Energy Forum 2012 June 4 – June 8, 2012, Manila, Philippines

The Asian Development Bank (ADB) and the US Agency for International Development (USAID) are pleased to announce the dates for the Asia Clean Energy Forum 2012.

USAID and ADB have jointly organized the Asia Clean Energy Forum (ACEF) since 2006, with the aim of sharing best practices in policy, technology, and finance to meet the region's climate and energy security challenges. The 2011 Forum was attended by more than 600 people from 55 countries, and attracted more than 160 speakers.

In 2012, the Forum will highlight successful strategies and mechanisms for accelerating access to affordable, low-carbon energy. Participants from Asia and around the world will share practical knowledge about what really works in the key areas of energy access, clean energy technology, policy and regulation, and finance and how the stakeholders can work together to accelerate low carbon energy in the region.

Information and updates on ACEF can be found on: www.adb.org/ACEF or www.asiacleanenergyforum.org

Rio+20 United National Conference on Sustainable Development June 20-22, 2012, Rio de Janeiro, Brazil

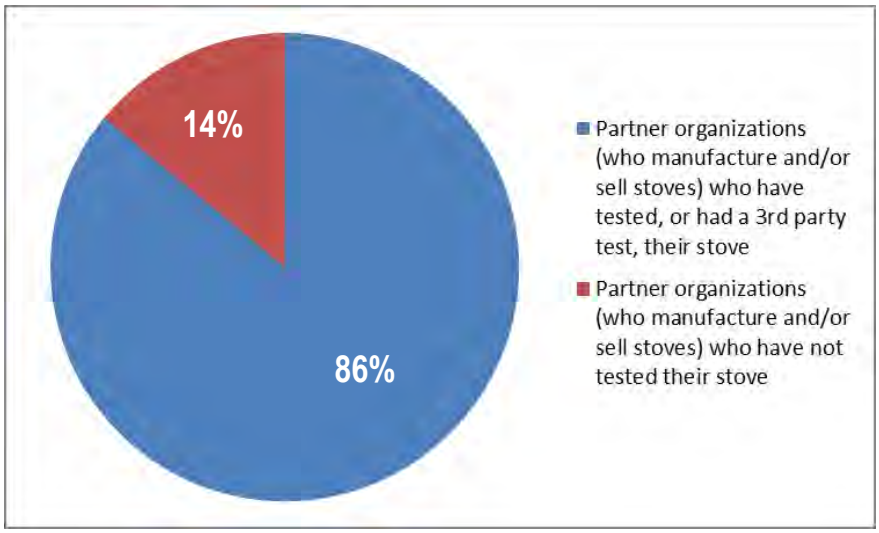
At the Rio+20 Conference, world leaders, along with thousands of participants from governments, the private sector, NGOs and other groups, will come together to shape how we can reduce poverty, advance social equity and ensure environmental protection.

The United Nations Conference on Sustainable Development (UNCSD) will take place in Brazil on 20-22 June 2012 to mark the 20th anniversary of the 1992 United Nations Conference on Environment and Development (UNCED), in Rio de Janeiro, and the 10th anniversary of the 2002 World Summit on Sustainable Development (WSSD) in Johannesburg.

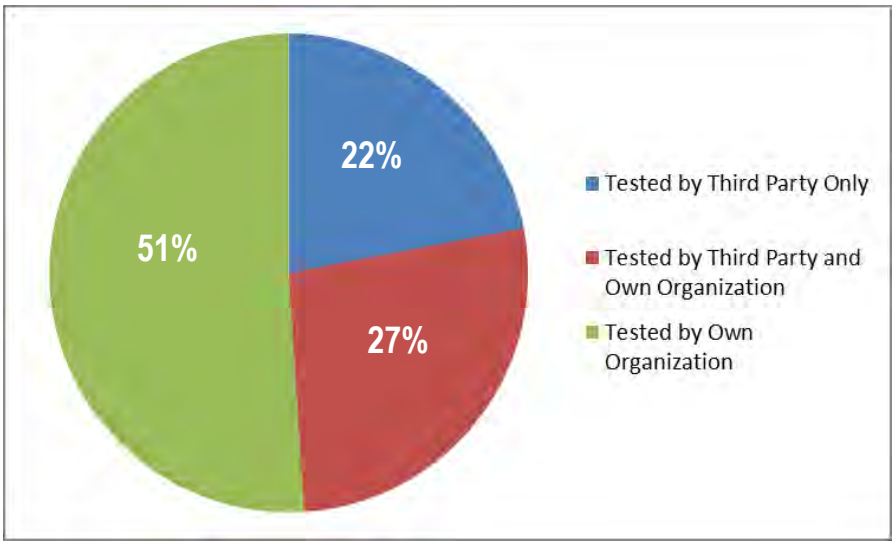
Energy is one of the 7 critical issues that will be addressed at Rio+20. For more information, please visit http://www.uncsd2012.org/rio20/index.html

FACT BOX — Testing Statistics from 2011 PCIA Partner Results Reports

86% of PCIA Partners who reported manufacturing and/or selling stoves in 2011 have tested their stove's performance!



Nearly half (49%) of those Partners who reported testing their stove had a third party conduct some or all of the testing



WHICH TESTS ARE BEING CONDUCTED? Of the reporting PCIA Partners who have tested their stoves:
83% have conducted the WBT
53% have conducted the KPT
47% have conducted the CCT
39% have tested emissions
37% have conducted Indoor Air Pollution monitoring

WHAT OTHER INDICATORS ARE EVALUATED? Of the reporting PCIA Partners who have tested their stoves:
87% monitor/evaluate cooking time
79% monitor/evaluate user acceptance
60% monitor/evaluate safety
57% monitor/evaluate adoption/usage
56% monitor/evaluate durability
43% monitor/evaluate time spent gathering fuel