ETHOS 2016 Abstract Catalog
-talks organized by order on the agenda

Saturday morning DOE session

David Stokes, RTI International

Title: Lab-to-Field Performance of a Thermoelectric Enhanced Cookstove Add-on for Rocket Stoves

Abstract: Under a DOE program, RTI has demonstrated a solution to enhance existing biomass cookstove performance through the use of a Thermoelectric Enhanced Cookstove Add-on (TECA) device. The self-powered TECA device captures a portion of heat from the stove and converts it to electricity through a thermoelectric (TE) device to power a blower. Colorado State University and Envirofit International are partners to support the air injection design and commercialization to enhance combustion in the stove and reduce emissions.

We have applied a proof of concept of the approach with the Envirofit M-5000 stove and TECA device with tests in the lab and the field. Under this program we demonstrated PM emissions at 82 mg/MJd in the lab, a 70% reduction as compared to baseline stove operation. With field testing in Aurangabad, India, we have reproduced these results with both technician and local users operating the two stoves. We will present the results of the lab testing and both the methodology and results of our field testing.

Vi Rapp, Lawrence Berkeley National Laboratory

Title: Using forced-air to reduce particulate emissions from biomass cookstoves: Are we reducing the health risk?

Abstract: In order to address the world's greatest environmental health risk (3.6 million premature deaths per year caused by pollution exposure from cooking on biomass fires) researchers have focused on producing new cookstove designs that significantly reduce harmful biomass emissions, primarily focusing on particulate matter (PM). Previous research reveals that judiciously introducing turbulence (via forced-air injection) into the combustion zone can dramatically reduce the overall mass of PM generated by biomass combustion. However, researchers are unclear if the addition of forced-air injection is reducing all sizes of PM emissions uniformly or generating a greater number of ultrafine particles, which could be more harmful to human health. In this presentation, we will discuss the impact of several forced-air injection designs on cookstove performance and emissions. For each design, emission concentrations for particles ranging from 5 nm to 20 um in diameter were measured during multiple high-power water boiling tests (~5.2 kW firepower).

Tim Theiss, Oak Ridge National Laboratory

Title: Materials for Corrosion-Resistant Metallic Combustors in Low-Cost, Clean Biomass Cookstoves

Abstract: The success of clean biomass cookstoves with improved efficiencies and reduced emissions is critically dependent on the materials of construction. The most challenging component is the combustor, which must operate at high temperatures (often > 600°C) in the presence of aggressive oxidizing species (water vapor, chlorine, sulfur, salts and deposits) derived from the combustion of the

biomass fuel. Such conditions pose a significant materials durability challenge considering the need for low cost materials to permit widespread cookstove adoption. This presentation will overview the final findings from a recent Department of Energy funded project to develop in-situ cookstove and laboratory furnace corrosion test protocols, and evaluate a range of commercial and developmental metallic combustor materials. FeCrAlY exhibited the best corrosion resistance of the commercial alloys examined (FeCrAlY and types 310, 446, 316L, and 201 stainless steels). However, one of the developmental alloys, a ferritic FeCrSi-base, showed early promise for improved corrosion resistance over that of FeCrAlY, at potentially lower cost. Several coating approach concepts were also evaluated, with pre-oxidation, nickel (as a possible cladding), and thermally sprayed zirconia exhibiting some promise but requiring further development.

Jonathan Posner, University of Washington

Title: Design of a Commercially Viable Natural Draft, Clean Cookstove for East Africa

Abstract: We will present our work on the development of a commercially viable, natural draft cookstove that will exceed ISO tier 4 criteria while meeting the needs of rural and urban cooks in East Africa. We will deliver a market ready cookstove that meets the manufacturing cost and usability expectations of the final users, including durability, safety, comfort, aspirational value and compatibility with local fuels, foods, and customs.

Saturday morning breakout session

Seema Patel, Global Alliance for Clean Cookstoves

Title: Fuels for Thought: Resources for the Cooking Fuels Sector

Abstract: To truly be effective, clean cooking solutions must consider stoves AND fuels. The Global Alliance has developed a suite of activities and tools designed to strengthen fuel value chains, enable stakeholder decision-making, and build advocacy and support within the sector. A variety of tools will be presented that will help stakeholder to evaluate benefits and tradeoffs for fuel options, identify ways to improve their environmental impacts, and guide future research, development, policy, and implementation work. Resources that will be discussed include:

- Evaluations of fuel supply and environmental impacts to strengthen fuel enterprise business models
- An enhanced global database of cookstoves, fuels, fuel products and performance data
- A comparative analysis tool of environmental, economic and social impacts of fuels for cooking
- Future activities that will strengthen country fuel efforts

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Sameer Patel, Washington University in Saint Louis

Title: A model for cost-benefit analysis of cooking fuel alternatives

Abstract: Nearly half of the world's population does not have access to cleaner cooking fuels, and this is attributed to several things including the lack of resources (fuel), infrastructure (production and distribution), purchasing power (poverty), relevant policies, and a combination of these reasons. A

household's fuel choice aims to minimize cost and maximize benefit, both of which are intricate functions of many factors. The factors influencing a household's fuel preference, and how manipulating these factors such as subsidies, improved distribution networks and user awareness will affect fuel preference is reported. A cost-benefit analysis (CBA) model was developed to study the fuel preferences of rural Indian households. Seven cooking fuels (biomass, dung, charcoal, LPG, biogas, kerosene and electricity) were ranked in order of household preference. Various scenarios were considered to demonstrate the sensitivity of fuel preference to multiple factors such as subsidies and improvement in cooking technology. Though this work focused on rural India, the model used can be easily translated to both the rural and urban populations of other countries with only minor modifications to suit the demographics, geography, market conditions and policies of that country.

Kristen Fedak, Colorado State University

Title: How Clean is Clean Enough? A Controlled Cookstove Exposure Study

Abstract: A logical hypothesis is that adoption of "clean" cookstoves will reduce emissions and improve health compared to traditional cookstoves. Yet, few studies have quantitatively tested this hypothesis. There are many gaps in our understanding of how pollution profiles differ across stove types and the relevance of these differences for health. A variety of factors related to fuel type, stove type, and operating procedure likely play a role in determining air pollutant emissions from various stove technologies. As we strive to balance health, fuel efficiency, climate, practicality, and affordability in their design of cookstove technologies, it is important that we answer the question "how clean is clean enough?". In this presentation, I will discuss the beginning stages of an NIH-funded research project that aims to address this question. The goals of this study are to 1) characterize health-relevant emissions profiles for a variety of stove and fuel combinations, including unique fuels used during stove start-up or ignition such as plastic bags, rubber, and agricultural waste, and 2) conduct a controlled human exposure study to investigate the association between markers of cardiorespiratory health and exposure to emissions representing a range of "clean" stoves.

Michael Naleid, Winrock International

Title: Update on Winrock & U.S. EPA Capacity Building and Technical Assistance Program

Abstract: Since the integration of PCIA and the Global Alliance for Clean Cookstoves in 2012, Winrock and the U.S. EPA have continued working to increase the exchange of technical information among public and private organizations working in the global household energy and health sectors through local capacity building, targeted technical assistance and field studies and global knowledge sharing. The goal of these activities is to promote effective approaches that lead to increased use of clean, reliable, affordable, efficient, and safe home cooking and heating practices. In 2015 Winrock and the U.S. EPA organized and facilitated 6 webinars, 1 workshop and 1 field study, and continued to provide support for the ISO TC 285 process. The workshop was focused on a new curriculum, measuring and understanding household energy use, and a field study was conducted post-workshop with the workshop host. The primary objective of this training workshop and field testing opportunity was to provide NGOs and businesses working in the clean cooking sector with the knowledge and skills to comprehensively and effectively assess and understand patterns of adoption and use of clean cooking interventions, with the aim of providing valid, robust data to facilitate and guide best practice. Two additional stove usage workshops are planned for 2016.

Adam Creighton, InStove

Title: Novel Agricultural Applications for Institutional Biomass Cookstoves

Abstract: The InStove institutional rocket stove was originally designed to efficiently prepare large amounts of food. However, 2015 saw the discovery and development of novel agricultural applications for institutional biomass rocket stoves including processing of shea and poultry, alcohol production, greenhouse/hydronic heating, and high-capacity canning.

Neeraja Penumetcha, Global Alliance for Clean Cookstoves

Title: What's Cooking in the Clean Cooking Catalog: Cataloging Innovation in the Sector

Abstract: The Global Alliance for Clean Cookstoves has developed an extensive repository of performance and safety data from the past 20 years. This presentation delves into this data by stove and fuel type to:

- Identify high-level trends
- Describe efficiency and emissions performance
- Compare lab and field test results
- Identify gaps in the available test data

James Tillotson, Colorado State University

Title: Effects of stove design and fuel bed parameters on overall emissions from and power output of a TLUD

Abstract: A laboratory study was conducted using a heavily instrumented, modular top-lit updraft gasifier cookstove. Experiments were conducted in which primary air flow rate, ratio of secondary to primary air flow, secondary air delivery parameters (e.g. temperature, jet velocity, swirl angle, and downward angle), pot gap, and fuel bed properties (e.g. fuel type, moisture content, and bulk density) were varied. A new test procedure was designed to capture three different modes of stove operation (normal, refueling, and char burnout). During each operating mode, carbon monoxide emissions, particulate matter emissions, and useful power output were measured. The syngas leaving the fuel bed and entering the secondary combustion zone was also sampled and analyzed to determine H2, CO, CH4, O2, CO2, and N2 content. The stove design parameter that had the greatest influence on emissions was secondary air jet velocity. Linear relationships between primary air flow rate and useful power output, as well as fuel moisture content and useful power output, were identified. Overall, fuel type and operating mode influenced syngas composition and cookstove emissions more strongly than cookstove design. In addition, thermocouple and gas composition data indicated that the biomass gasification process was fundamentally different during the three operating modes.

Paul "Dr TLUD" Anderson, Juntos Energy Solutions NFP

Title: Ten TLUD Activities with Direct Dr TLUD Participation in 2015-2016

Abstract: Worldwide enthusiasm for Top-Lit UpDraft (TLUD) micro-gasification has stimulated numerous independent TLUD activities. TLUD projects that have DIRECT involvement by Dr TLUD are summarized by geographic areas.

A. Africa:

1. Uganda and Kenya: Refining the TChar variation of TLUDs, including Jiko Koa charcoal stoves.
2. Ghana: Production of ND (Natural Draft) TLUDs, some FA (Fan Assisted) TLUDs, local fuels of pellets and bamboo, with pilot projects.
3. South Africa: Developing a Fan Assisted Appliance Base that includes TLUD-FA gasifiers, 3 options of electrical power, and attachments.
4. Cameroon, Sierra Leone, and Ethiopia: Solid contacts for new initiatives.

B. Latin America:

5. Guatemala: Introduction of TLUD stoves and biochar for environmental protection around Lake Atitlan.
6. Haiti: TLUD stoves specifically for low-density briquette fuel, with attention to biochar in weak Haitian soils.

C. Multi-national efforts:

7. Vietnam and USA: Continuing development of TLUD-RH-F2A stoves (rice husk fuel with forced secondary air).
8. Bangladesh and Canada: TLUD stoves with clay and brick components for lower costs.
9. Guatemala, El Salvador, USA (Hawaii & Illinois), Ghana, Brazil and Ecuador: Barrel-sized kilns using "flame curtain" techniques for biochar production.
10. Portugal and USA: A high-end, moderate-priced continuous-operation gasifier w/ multiple burners.

Saturday afternoon break-out session

Vahid Jahangiri, International Lifeline Fund

Title: Creative Distribution Models in Haiti and Uganda

Abstract: Given the challenges of stove distribution in rural settings, ILF integrated its rural stove program with its WASH program in Northern Uganda. The WASH program provides clean water to 75 villages where community clubs (CC) provide hygiene and sanitation training for period of 20 weeks. The CCs were used as a platform to sell stoves to the households via a credit scheme where the households would pay for their firewood stoves in small increments. The program has sold over 3500 stoves to the communities. Various statistics will be shared on this program which would valuable for the attendees especially in regards to the relationship of how households view financing mechanism and the importance of having a fuel efficient stove. In Uganda, ILF & D&E are piloting 3 programs in distributing charcoal stoves., 1) through a Plastic collection center, 2) large factory employees, 3) wholesale charcoal purchase for communities and promoting FES.

Luni Libes, Fledge

Title: Accidentally building and selling 250,000 cookstoves... profitably

Abstract: Obamastove of Ethiopia is a unique story in cookstoves. Founded by a refugee taxi driver, created to help his family, accidentally growing to be one of the largest cookstoves companies in Africa, producing over 250,000 stoves to-date, profitably.

This is a story that needs not to be unique. We need companies like Obamastove in dozens of countries around the world, and we'd love to share this story with the goal of sharing the details with other cookstove manufacturers in other countries to replicate the Obamastove processes everywhere where they can be replicated.

Hear a short version of the story firsthand at http://www.obamastove.com/.

Dave Lello, Ekasi Energy

Title: Bridging the price gap between ND TLUDs and FA TLUDs with a PAYG option.

Abstract: Pay as you go (PAYG) payment options are being used successfully in Solar Lighting Systems across many countries. In fact the fan used in the TLUD can be an accessory of the Solar System. Adding a fan and a fan speed controller to a solar system is simple and inexpensive.

The session will discuss how PAYG helps increase affordability, helps create a recurring income for a business selling stoves and brings the business of electricity access and clean cooking closer together.

We will also demonstrate a FA TLUD with a 2 in 1 function: Cooking and providing electricity.

This creates options to bundle electricity and stove fuel together. The increase in fuel efficiency on the stove can pay for the additional PAYG fees including other functions like mobile charging and lighting.

It is time to look at both electricity and cooking as part of the same problem and not as 2 different issues.

Ricardo Piedrahita, CU Boulder

Title: Multi-method assessment of cookstove stacking in Northern Ghana

Abstract: This work provides a systematic, multi-method assessment of households' cooking behaviors and cookstove stacking in the context of a 200-home randomized cookstove intervention study in Northern Ghana. Two stoves were selected for the intervention, a locally made rocket stove (Gyapa) and the Philips HD4012 LS gasifier stove. There were four intervention arms: a control group, a group given two Gyapa stoves, a group given two Philips stoves, and a group given one of each. Two stoves were distributed to each home in an attempt to induce more substitution away from traditional stoves. Adoption and usage patterns were quantified using temperature loggers at a subset of homes, as well as quarterly surveying in all households. The two assessment methods are compared directly, and survey data are used to explain reasons for observed usage trends.

Tara Ramanathan, Nexleaf Analytics

Title: Cloud-Based Monitoring to Understand Adoption: 3 Case Studies from the field

Abstract: After 15 months of monitoring Forced Draft stove usage in 29 villages in India, we have seen the value of combining sensor data with survey data to understand stove adoption. Your sensor data may have detected that Household A uses the ICS on average 1 hour daily. Does that mean they did not want to use the stove, or they could not for external reasons that could be resolved? The point is that, similar to survey data, sensor data alone may not give us the full story on stove adoption. We have three case studies that show the positive outcome of gathering as many data points as possible before drawing a conclusion about stove adoption. Finally, we want to highlight that remote monitoring allows you to immediately see what sensors stopped collecting data and fix the device so you don't lose important data.

Daniel Wilson, UC Berkeley

Title: Effects of USB Ports on Use and Misuse of TEG Cookstoves

Abstract: With the new availability of USB ports on TEG-enabled cookstoves, stakeholders are curious about how these USB ports influence adoption. The capability of off-grid charging could conceivably affect cookstove adoption in many ways. The possibility of TEG cookstoves leading to cookstove "misuse" is of great concern to policy makers and stakeholders in the cookstove space. If a customer chooses to use a cookstove solely for charging purposes, she might exposure herself and her family to higher daily doses of dangerous emissions than if she never obtained to "clean cookstove" in the first place -- even a very clean cookstove will contribute to increased exposure if the cookstove is not displacing dirtier cooking technology for the purpose of making meals. The emergence of TEG cookstove on the global marketplace and the potential risks associated with this technology highlights the need to understand TEG-enabled USB charging impacts cookstove adoption. In this study, we explore how the presence of USB ports on fan-powered cookstoves influences adoption. We measure the impacts of USB on the number of fires made in the cookstove, and we also measure whether those fires were used for cooking or not.

Sari Mira, University of Dayton (rep Joshua Heyne)

Title: Reduced Order Experimental Configuration Studies of Wood Combustion

Abstract: Wood is one of the largest biomass energy resources used today. Yet, the combustion process of wood is still largely optimized. While theoretically wood is a renewable source of energy, it is not necessarily a clean source as the process of wood combustion is inherently multidimensional and multiphase, and the formation of emissions such as CO, NOx, and other particulates are results of both deficient and copious mixing. Thus, standard experiments characterizing the emissions/speciation and performance of wood combustion using various fundamental and applied experimental configurations can contribute in part to the reduction of emissions and increases in efficiency. Previous, studies towards this aim have focused on experimental configurations similar to so-called stove combustion (i.e. multiphase multidimensional). Here, we propose an experimental configuration in which the initial/boundary conditions are both well characterized and entirely gaseous, and the geometry can be modeled as zero or one dimensional. Thus, a preliminary study of gas-phase wood specific species was conducted in order to design and speculate the potential benefits of these reduced order experimental

configurations. Results of one of these experimental configurations, a counterflow diffusion flame experiment, are reported following the work of Ranzi et al. (Ranzi, Couci, Faravelli, et al., 2008).

Kelsey Bilsback, Colorado State University

Title: A Novel Approach to Cookstove Testing: The Firepower Test Sweep

Abstract: Currently, the cookstove sector relies heavily on task-based laboratory protocols, which characterize stove performance under a highly restricted set of operating conditions. A firepower sweep test was developed to assess cookstove emissions more holistically in a laboratory setting. The protocol was designed to reproduce field-relevant operating conditions in a laboratory setting, where emissions testing is less costly and less logistically difficult, and where a fuller suite of emissions instrumentation can be employed to provide more detailed stove emissions measurements. Twenty-four different stove/fuel combinations were tested using the protocol. When compared with field studies in the literature, the firepower sweep tests are able to reproduce the large variability and high emissions factors that are not typically captured in a laboratory setting. The results also demonstrate that firepower can predict a large amount of the variance in black carbon emissions from a given stove/fuel combination. Multi-linear regression analysis showed that 66 to 95 percent of the variance in $PM_{2.5}$ is explained when modified combustion efficiency and firepower are used as predictors. Finally, several field campaigns were conducted concurrently, which measured the characteristics of uncontrolled cookstove emissions. Initial validation of the laboratory parameterizations with data from the field campaigns shows promise.

Kathleen Lask, Lawrence Berkeley National Lab

Title: Effect of Lighting Cone on Charcoal Stoves

Abstract: In many stoves, it is initially difficult to achieve the draft (upward air flow) required to create a self-sustaining flow of oxygen through the fuel bed, so the combustion processes are stifled and inefficient, leading to slow ignition times. A lighting cone is a simple metal cone placed on the fuel bed during ignition to act as a chimney, increasing draft through the fuel bed; it is used in various parts of the world as an inexpensive accessory to help with ignition.

This research explored the effects of a lighting cone on a traditional Haitian charcoal cookstove using several instruments to monitor emissions (such as carbon monoxide, black carbon, and ultrafine particulates) and fuel consumption during ignition. It aimed not only to evaluate the effectiveness of a lighting cone in reducing ignition time, but also to examine what impact it has (positive, negative, or neutral) on the fuel consumption and emissions from a charcoal-burning stove during its ignition phase.

Sunday morning DOE session

Jessica Tryner, Colorado State University

Title: When is a TLUD not a TLUD?

Abstract: The goals of our DOE-funded project are to gain an improved understanding of: (1) the combustion process in a top-lit up-draft (TLUD) gasifier cookstove and (2) how various operational and cookstove design parameters affect performance in terms of emissions and efficiency. We are pursuing these goals through coordinated experimental and modeling efforts. The experimental effort involves: (1) measuring emissions, power output, and syngas composition in the laboratory using a parametric TLUD test bed and (2) collecting high-speed PLIF images of the secondary combustion zone in a two-dimensional TLUD test bed with optical access. The modeling effort involves: (1) development of two chemical kinetic mechanisms (one for the oxidative pyrolysis process that takes place in the fuel bed and another for the combustion process that takes place in the secondary combustion zone) and (2) development of a fourth-order CFD code to model the secondary combustion zone.

Dean Still, Aprovecho Research Center

Title: "Clean Burning Biomass Cookstoves" and SSM to Manufacture Side Feed Forced Air Rocket Stove with Chimney

Abstract: ARC used an iterative development and modelling approach to create five 'Tier 4' cook stove prototypes (ND-TLUD, ND-Rocket, ND-Charcoal, FD-Side Feed, and FD-Top Feed) in the lab using the WBT and the LEMS emission hood. The stoves were field tested with the CCT/LEMS in Ghana, Senegal, India, Nepal, Kenya, Central America, Peru, and China. The CCT data was used to refine the stove prototypes. A journal article (Still, et al, EcoHealth, 2015) and book (Clean Burning Biomass Cookstoves, 2016) summarize the findings. The book will be translated into Chinese and published in China. The plan is for Shengzhou Stoves to manufacture the 56% thermal efficiency FD-Side Feed Rocket Stove, to be sold in 60 countries by a US based distributor.

Michael Johnson, Berkeley Air Monitoring Group

Title: Platform for Integrated Cookstove Assessment

Abstract: Monitoring health and environmental benefits in the household energy sector would be aided by reliable, user-friendly, and low-cost tools for assessing key indicators such as air quality and stove usage. The Platform for Integrated Cookstove Assessment (PICA) is being developed by Berkeley Air Monitoring Group, UC Berkeley, and EME Systems, with funding support from the U.S. Department of Energy, to address this need. PICA builds on our experience with inexpensive, data-logging, portable pollutant sensors by providing software that manages instrumentation and integrates data in one easy-to-use, harmonized platform. This presentation will include findings from laboratory and field testing of PICA's air quality (PATS+) and stove usage monitors (SUMS), including recent results of PATS+ performance during a field study in Laos. PATS+ is extensible, with optional carbon monoxide and movement sensors, and battery packs which can extend deployment periods for up to several weeks. Improvements to SUMS include rapid analysis of temperature traces to determine duration and number of cooking events per monitoring period and additional sensors for easier assessment of traditional or non-uniform stoves.

Sunday morning break-out session #1

Sam Bentson, Aprovecho Research Center

Title: A Planning Tool for Stove Developers: With Indoor/Outdoor Air Modeling

Abstract: Aprovecho Research Center has created an Excel based tool to help stove developers and policy makers decide on the appropriate intervention to combat indoor air pollution. The tool uses the same indoor air quality model as the 2014 WHO indoor air guidelines, and also uses it to consider the effect on outdoor air pollution of a population using stoves with a given emissions rate. The user can specify the stove emissions rate over a 24hr period, chimney efficiency, room air exchange rate, room size, number of stoves in the population, and properties of the outside environment, and will be given the indoor and outdoor pollutant concentrations.

Dale Andreatta, SEA, Ltd.

Title: Pot Skirts as a Means of Improving Efficiency of Plancha Stoves

Abstract: Plancha stoves have many practical advantages, the pots stay clean, the smoke is vented out through the chimney, many pots can be heated at once, and tortillas can be cooked. For high energy cooking tasks, however (for example, boiling a pot of beans) the efficiency is low.

It is possible to put a skirt around the pot, such that heat is drawn from a larger area of the plancha, decreasing cooking time and fuel use. This presentation gives the results of a series of tests covering a set of options for building such a skirt. Test results are given for two pots, a flat-bottom pot and the same pot sitting on bumps to simulate a well-used pot with a dented bottom. Test results are given for the most promising skirt design in terms of heat transfer (Watts), heat transfer efficiency (%), time to boil, and minimum fire power (Watts) required to simmer. Practical aspects of such a skirt are explored.

Anamol Pundle, University of Washington

Title: Predicting Natural Draft Rocket Stove Performance Using Computational Fluid Dynamics

Abstract: We present the development of and results from computational fluid dynamics (CFD) models of a natural draft, rocket cookstove. The simulations account for fluid flow, heat transfer including radiation and losses to the environment, as well as model combustion using a finite laminar rate model and a reduced chemical kinetic mechanism. The models provide critical stove performance metrics such as heat transfer efficiency as well as more detailed information such as temperature distributions, flow fields, and excess air that are useful in stove design. We will describe two models, an axisymmetric RANS and a three-dimensional transient LES, and will provide discussion on the challenges and advantages of each model in the context of providing insight into practical stove design as well as fundamental combustion and flow physics of natural draft cookstoves.

Garrett Allawatt, University of Washington/Burn Design Labs

Title: A simple heat tranfer model and applications to stove design

Abstract: We present the guiding principles and operation of a simple design tool that predicts efficiency of natural draft rocket stoves. The design tool can predict time resolved component temperature, overall stove efficiency, and total flow rate using stove geometry, material parameters, and burn rate. An overview of heat transfer effects from conduction, convection, and radiation is presented. We demonstrate the design tool to investigate the key parameters that effect the performance for several commercially available cookstoves as well as UW/BDL rocket stove prototypes. The information obtained from this study has guided a series of stove design modifications resulting in a 20% increase in stove efficiency. We conclude our discussion with key stove design strategies for maximizing stove efficiency. The design tool will be available in a web based form.

Alex Seidel and Mike Hatfield, Aprovecho Research Center

Title: New Equipment Development at Aprovecho

Abstract: Over the course of 2015, Aprovecho Research Center has been developing two new major upgrades to its Laboratory Emissions Monitoring System (LEMS). One is an upgraded main sensor unit (Sensor Box) of the LEMS, which contains the CO, CO2, $PM_{2.5}$, and associated flow sensors. This upgrade improves the manufacturing process of the Sensor Box for a more robust final product, and also improves the response time of most of the individual sensors. This makes the overall LEMS system more accurate and more reliable. The second upgrade is an optional black carbon sampling system for the LEMS. This addition integrates with an existing LEMS system, and gives the user several filter collection options depending on the quantity of black carbon produced by the stove being tested. Pictures of the filters can then be uploaded to the NexLeaf online black carbon analysis, or the user can do their own analysis using any of several different black carbon measurement technologies available on the market today.

Julien Caubel, Ashok Gadgil Cookstove Group - UC Berkeley (rep Lamees Alkhamis)

Title: Recalibration of DustTrak for Biomass Cookstove Emissions

Abstract: The DustTrak DRX Aerosol Monitor device measures mass fraction concentration of fine particles produced from indoor and outdoor air emissions using a light scattering technique. However, researchers report that the DustTrak commonly overestimates biomass particulate matter (PM) concentrations because it is calibrated using a standard for highly reflective Arizona road dust. This study aims to better understand how DustTrak measures $PM_{2.5}$ from biomass stoves in low (~10mg/m^3) and high concentration (~100 mg/m^3) regimes compared to the concentrations measured gravimetrically with Teflon filters. To obtain a calibration curve for the DustTrak, we compared DustTrak and filter measurements from multiple, unscented incense sticks. The incense sticks produced particles around ~100nm in size. High $PM_{2.5}$ concentrations were achieved by increasing the number of incense sticks and, separately, by operating the Berkeley-Darfur Stove at high power (cold start).

Lara Egbeola-Martial, UC Berkeley

Title: Quartz filters as a reliable and economical alternative to Teflon filters for measuring gravimetric $PM_{2.5}$ emissions

Abstract: The EPA currently recommends the use of Teflon filters for measuring gravimetric $PM_{2.5}$ emissions from biomass cookstoves. However, Teflon filters are expensive (8$ per filter) and can be a significant economic burden during replicate testing of stoves in a developing country. Quartz filters (2$ per filter) are a more affordable alternative for $PM_{2.5}$ gravimetric analyses but their accuracy can be questionable since they are fragile, shed fibers easily, and may adsorb organic gases during sample collection. To test the accuracy and reliability of quartz filters, we carefully compared gravimetric measurement of $PM_{2.5}$ particulate mass from biomass combustion obtained with Teflon and quartz filters under near-identical conditions. Our aim is to determine the error in the measurements obtained with quartz filters, using measurements from Teflon as the baseline. $PM_{2.5}$ emissions were collected from unscented incense stick and the Berkeley Darfur stove operated at high power (cold start). The highly encouraging results could substantially reduce the cost of emissions testing of stoves in developing country labs.

Ryan Thompson

Title: Emission Measurement Equipment: Behind the Lies

Abstract: The presentation will start with a brief synopsis of the emissions equipment industry with a focus on applications for solid fuel combustion appliances. The current need for emission measurements and emissions equipment will be framed. Technological advancements and technological challenges in emissions monitoring equipment will be explored, which will segue into a presentation of current emissions equipment development projects at the Mountain Air Research Facility. Then the podium will open to the audience for jokes and funny comments.

Paul Means, Burn Design Lab

Title: Beyond the WBT: User Research and Cookstove Development

Abstract: As part of the natural draft rocket stove development funded by US DOE and conducted by the University of Washington and Burn Design Lab, substantial user research was conducted which helped to identify user preferences for cookstove attributes. Along with user preferences, data on fuel and pot sizes was collected to better understand cookstove operating conditions. Fuel size, pot type and size, tending frequency, and fuel moisture may vary markedly between the field and the conditions of the typical laboratory water boiling test. Initial test data shows a substantial impact on stove performance associated with the differences between the values of these parameters in the field vs. in the test lab. Identifying and matching the laboratory test conditions with those in the field may lead to lab test results that better correlate with field test results, and so form a more reliable basis for stove design.

Elisa Derby, Winrock International/WASHplus

Title: Consumer Research Toolkit for Improved Cooking Technology Options

Abstract: Improved cooking interventions only succeed when consumers like and use their new stoves, but they are often left out of the cookstove design and/or selection process. To better reflect user perspectives and improve effectiveness of programming seeking adoption of cooking stoves with increased efficiency and/or reduced emissions, the USAID WASHplus project is developing a consumer preference and willingness to pay toolkit, based on multi-methods research in Bangladesh and Nepal. The toolkit includes methods, question guides and analysis templates for a range of quanti- and qualitative techniques, sample reports and presentations, budgets and logistics tips, and guidance on how to adapt and use them in a variety of settings. The interactive presentation will review the toolkit and how to access and adapt it.

Daniel Wilson, UC Berkeley

Title: The SUMsarizer: Anyone Can Analyze SUMs Data

Abstract: Using low-cost, data-logging thermometers called stove use monitors (SUMs), it is possible to track the usage of intervention and traditional stoves over time (Thomas, 2013; Wilson, 2015; Pillarisetti, 2014; Ruiz-Mercado 2008, 2011, 2013). While a number of methods exist for analyzing data from these thermometers, most rely on programming skill or are clunky, slow, file-by-file solutions using commercial spreadsheet software. These large data sets can include hundreds of individual cookstove users monitored for months at a time. Skilled staff must program a SUMs data analysis tool in R, MATLAB, Python, or similar language that can analyze the “big data” that comes out of a statistically meaningful SUMs deployment. Analyzing SUMs data presented a clear bottleneck stakeholders in cookstoves work. This was the impetus for our team to create “The SUMsarizer.” The SUMsarizer is an easy-to-use graphical tool that allows coding-naive stakeholders (such as NGOs and technology implementation agencies) to make data-driven decisions about cookstoves. SUMsarizer uses modern statistical techniques and “expert” knowledge (supervised learning) about cookstove use to simplify the process of analyzing iButton data. Leveraging web visualization and interactivity tools, SUMsarizer allows users to quickly upload and view stove usage datasets.

Nordica MacCarty, Oregon State University

Title: Integrated modeling and field studies for village energy systems

Abstract: Engineering systems modeling tools are useful to help understand the applications and outcomes of energy technologies such as cookstoves within the larger village energy system. An integrated model can link new and existing models from differing sectors, technologies, and scales in order to help create a more holistic understanding of the community energy system. Such a model can aid in understanding the effects of technology and policy design choices on multiple objectives including energy access, health and climate impacts, economic costs, and social benefits by taking into account application factors such as usability, stacking, rebound, opportunity costs, and multi-functionality of devices. A newly-established research group at Oregon State University will continue to develop these sorts of design and modeling tools and validate them with field studies in Guatemala conducted by undergraduate students in collaboration with StoveTeam International.

Sunday morning break-out session #2

Pete Schwartz, Cal Poly, San Luis Obispo

Title: Solar Electric Cooking: Coming Soon?

Abstract: A photovoltaic powered, electronically controlled heater can cook dinner for a family of six in a well insulated oven, requiring no fuel. This technology is readily adaptable to frying, baking, and boiling. A heated thermal mass can keep the cooking chamber hot into the morning. The present cost of about $150 should drop by half in five years with greater cooking power available for more cost. An ancillary benefit of this technology is to speed rural electrification for the poor. With continued decline in cost of solar cells, future electric cooking options will be more powerful and more convenient. Our research group is reaching out to communities in Africa in order to collaboratively develop these technologies to adapt to different cooking styles and availability of local building materials. Our intention is to have a working technology by the time the appropriate price point is reached, which for some communities may be very soon.

Larry Winiarski,

Title: Rocket Cyclone Incinerator

Abstract: This paper will introduce the rocket cyclone incinerator which can cleanly burn even plastic or medical wastes using natural draft and various biomass fuels. Two methods of construction will be shown: One method uses local material to build on site. Another method uses imported materials to make a portable, trailer mounted unit.

Michael Johnson, Berkeley Air Monitoring Group

Title: In-field black carbon emissions from cookstoves in Asia and Africa

Abstract: There is much interest in the climate impacts from cookstoves, especially relating to emissions of short-lived climate pollutants such as black carbon (BC). While reducing BC emissions within the household energy sector has potential for positive climate and health impacts, there are few field studies which have attempted to characterize the reductions that different stove types may provide. Here we present results on BC emissions from approximately 500 uncontrolled cooking events from studies in Africa and Asia. The studies included assessments of traditional, rocket, natural and forced draft gasifier, and charcoal stoves. Results suggest that non-traditional stoves generally reduced overall BC emissions due to lower emission factors reduced fuel use. The ratio of BC to particulate matter tended to be higher for the new stoves compared to traditional stoves, however, implying that the aerosol emissions were more warming per unit mass emitted, and thus the extent of their climate benefits is not straightforward. Comparison with laboratory estimates show similar trends, although the BC ratios are systematically higher from laboratory tests, presumably due to less smoldering combustion during controlled testing.

Erin Rasmussen, Independent

Title: Natural charcoals, so much more than a cooking fuel.

Abstract: Tom Miles and I have a paper being published on the use of biochar to filter contaminants from stormwater systems. There are projects like the one by Josh Kearns to filter drinking water systems with natural charcoals (produced in kilns that are basically scaled up stoves), and Art Donnely's project where coffee plantation workers use biochar to improve their kitchen gardens. I will talk a little bit about using biochar as a by-product of cooking stoves to and practical implications of using natural and activated charcoals to improve soils and water.

Indira Parajuli, Incheon National University (rep. Heekwan Lee, Ph.D)

Title: Air pollution and temperature distribution in a single cell house with wood burning cook stove

Abstract: Air quality in rural houses with open firing for cooking has been crucial in most of the single cell houses where people are using the same enclosure for cooking and their living purposes. Indoor Air Quality (IAQ) in wood burning space solely depends on firewood species and moisture content, stove type, ventilation, placement of chimney, etc. Moreover, as per the US EPA Particle Total Exposure Assessment Methodology (PTEAM) study, cooking is the second largest identified indoor source of pollution. The pollutants concentration inside single cell enclosure is many folds higher than threshold value for the safe health.

The purpose of this study was to investigate the indoor environmental conditions via the air velocity, temperature and pollutants (CO, CO2) concentration during cooking with firewood burning. Numerical simulations were conducted using Computational Fluid Dynamics (CFD) modeling to visualize the indoor concentration and temperature distribution. The standard k-ε turbulence model has been applied to solve the continuity, momentum, energy equations in a steady state with non - isothermal condition.

Field survey data was used in simulation to visualize the pollution distribution within indoor enclosure. The parameters used for the simulation are: 1) Stove heat source (Wm^3) (2) pollutants (CO, CO2) release from stove and from dwellers 3) Internal and external temperature difference. There is a strong agreement between measured and simulated CO, CO2 concentration distribution and temperature stratification inside enclosure. The pollutants distribution inside enclosure was found higher than the safe value within occupied zone which is causing ill health situation to dwellers. The modeled results have well correlated with the field monitored data of pollutants concentration as well as temperature stratification within the enclosure. The findings of this research can be helpful to simulate the better ventilation design for IAQ and comfort for the wood burning houses.

Katie Gross, Winrock International

Title: Empowered Entrepreneur Master Trainer Program

Abstract: Through funding provided by USAID, Winrock, in partnership with Johns Hopkins University and the Visionaria Network, has developed a Master Trainer Certification Program for trainers from locally-based cookstove companies and NGOs to become certified in delivering the Empowered Entrepreneur Training Handbook curriculum to cookstove entrepreneurs in their network. The handbook was developed through the Global Alliance for Clean Cookstoves to address the specific needs of female entrepreneurs and sales agents with regard to business, empowerment and leadership skills, although the training content is applicable for both men and women. The goal of the training is to equip

cookstove and fuel entrepreneurs with the knowledge, skills, and confidence to succeed in the clean cooking sector. It improves their capacity to make strategic choices and transfer those choices into desired actions and outcomes. Winrock has carried out one Master Trainer Workshop and certification program so far in Kenya (2015), and is currently preparing for another phase of the program in India (2016). Come learn more about the handbook, Winrock's activities in this area, and upcoming plans!

Cristel Cheong, Independent

Title: Malawi: Building to 2 million stoves by 2020

Abstract: In January 2013, Malawi's then president, Joyce Banda, committed Malawi to an ambitious national target of 2 million cookstoves by 2020. By end of 2013, Malawi's National Cookstoves Task Force was formed – a mix of public and private sector, civil society and donor community representatives.

The Task Force is now a Steering Committee, and in 2014 it adopted benchmarks against which stoves would be measured and counted toward the national target. These benchmarks were based on a discussion of what clean cookstoves mean for Malawi, and a subsequent redefinition of "clean" and decision to apply "CLEANER" as an acronym.

I will share with you the process behind Malawi's CLEANER cookstoves initiative and emphasize the important role played by nationwide stakeholder cooperation. I will also discuss how Malawi's annual Cleaner Cooking Camp (held every March since 2012) set the stage for many major milestones in Malawi's cookstove sector, solidifying Malawi as a regional leader in the push for cleaner cookstoves.

Timothy Lipp, Project Stoke

Title: Fire that Talks; Exploring the Connection between Ethnolinguistic Identity and Clean Cookstoves

Abstract: Identity based community development (IBCD) is an emerging field that seeks to understand how a communities ethnolinguistic makeup influence its development. The ethnolinguistic identity of communities could be directly influencing the varying levels of success in clean cookstove adoption. Ethnolinguistic identity is a foundational aspect of how a community interacts with its environment. Many countries where clean cookstove programs exist also have high linguistic diversity (Kenya for example has over 40 distinct languages, while India has over 400).

Cooking takes place within a highly cultural context, and many minority language communities have a robust awareness of immediate environmental concerns. Both of these factors make the intersection of Identity Based Community Development (IBDC) and clean cookstove technology a natural synergy. This is emerging research, of which the first phase is to understand (IBCD) in depth and create specific learnings from it to assist with clean cookstove adaptation, and provide some examples from other sectors. Future research will provide more robust guidelines and marketing implications.
