Award 1528811 - Annual Project Report

Accomplishments - What was done? What was learned?

If there is nothing significant to report during this reporting period, please check "Nothing to Report" if applicable.

* **What are the major goals of the project?**

This project seeks to understand how economic incentives ("prices"), social learning ("peers"), and subjective beliefs ("perceptions") interact to influence technology adoption dynamics. To do so, we will conduct a series of field experiments in the Kassena-Nankana Districts of Northern Ghana that offer improved cookstoves at different price levels to groups of households with and without social ties to households that have already received stoves during a prior study. Our specific goals are:

1. Obtain human subjects approval for study activities from participating institutions
2. Select improved stove models to be used in the intervention
3. Conduct formative research measuring willingness to pay for improved stoves in order to set range of price levels for intervention
4. Select study sample consisting of peer and non-peer group clusters
5. Conduct baseline survey with all study households
6. Make stove offers to households
7. Order and deliver stoves to households
8. Conduct follow up survey and instrument-based measurements of stove use and performance
9. Analyze study results
10. Disseminate results via peer-reviewed publications, websites, conferences, and community meetings

* **What was accomplished under these goals (you must provide information for at least one of the 4 categories below)?**

Major Activities:

1. Human subjects approval obtained from CU-Boulder and the NHRC
2. Stove selection process designed and initiated

In order to narrow down our search for biomass cookstove candidates to pilot test, an in-depth cookstove assessment was conducted. Two general types of stoves were targeted for this search: one comparable to the Philips gasifier stove used in REACCTING and the second to the custom-made rocket Gyapa wood stove also used in REACCTING. The assessment first consisted of generating criteria in which to select candidate stoves. Mainly, the stove candidates had to exhibit the same cooking principles as the targeted REACCTING cookstoves. Other criteria required the stoves burn primarily biomass fuels, be appropriate for the target population (i.e be capable of cooking local meals, be built to withstand local use etc), be available and affordable, and last but certainly not least perform as cleanly as possible. Cookstove literature and stove testing results were reviewed for the search. A list of stoves was generated, stove manufacturers were contacted and further investigations led to a final set of candidates. A summary of the assessment process is shown in the attached Figure 1.

A total of four stoves were tested according to modified Water Boiling Test standards, two of which were tested with a pot skirt apparatus. These stoves were the Envirofit M5000, Envirofit Econofire, Ecozoom Dura, and Greenway Jumbo, of which the Envirofit Econofire and EcoZoom Dura could be equipped with a pot skirt. Variables of importance to analyze from these Water Boiling Tests include heat transfer efficiency, fuel consumed, and time for 5L of water to reach 90 C. These variables were examined for both a cold start (fresh water with a room temperature pot and stove) and a hot start (fresh water with a just previously used pot and stove) as well as fuel consumed to simmer water for 45 minutes.

The next phase of testing will involve focus group discussions in the study area in which groups of women will cook a common dish (rice) with 3 different stoves and compare their performance. Users' feedback and preferences, along with the stove performance results from the lab testing described above, will be used to finalize selection of stoves for use in the intervention by October of 2016.

3. Stove use monitoring system development

One of the most informative metrics collected in a cookstove intervention is stove usage. These data can shed light on adoption, highlighting usage trends across stove types through time and space. Significant effort has been spent making stove use monitors (SUMs) effective, affordable and reliable on large scales in the field. Currently, no technology exists that fits all these criteria. Our research group has been committed to developing SUMs that come closer to meeting the needs of the cookstove research community. Thermocouples are ubiquitous in many industries and their temperature measurements are reliable. Costs of thermocouples have recently lowered due to increased manufacturing efficiencies, especially from China. Battery-powered thermocouple loggers were found that provide 32,000 readings and last 1-2 years on one ½ AA battery. These loggers are housed inside weatherproofed high density plastic enclosures and fastened to the cookstove body. The temperature measurement is made inside the stove body, usually between the outer cover and the combustion chamber.

Ungrounded thermocouples are required for reliable temperature measurements especially for metallic stoves. This new SUM design has been piloted in Navrongo, Ghana for the past 8 months and appears promising showing distinct cooking events. Stove-specific models will be developed to detect cooking events.

4. Focus group discussions held to generate willingness to pay estimates

The economic research in Year 1 was mostly in preparation for the main data collection and experimentation to be conducted in Years 2 and 3. Specifically, we required information on an approximate range for households' willingness to pay (WTP) for the different stove models. We elicited WTP in the focus group discussions (FGDs) conducted during our November 2015 field visit (see Figure 2). During each of these FGDs, we conducted a 2nd price, sealed-bid auction of different stove models with auction participants. Under classical economic assumptions, participants should bid their true ex ante WTP for the good (Krishna, 2009). The bid data from these FGD auctions therefore provide some guidance on the range of households' WTP for different stove models. We auctioned one 'mid/low-quality' and two 'high-quality' stove models.

References

Krishna, Vijay. *Auction Theory*. Academic press, 2009.

5. Geospatial database developed to facilitate sample selection

We also prepared a geospatial database for the study area with the objective of sampling villages for inclusion in the P3 experimental treatment and control groups based on their proximity to the original REACCTING study units. We worked on developing a GIS database combining standard layers from the NHRC for administrative boundaries, population centers, and major roads with geospatial data from the REACCTING study and the NHRC's demographic surveillance survey, including locations of study villages and households, treatment/control assignment from that study, and households' reported stove and fuel types (e.g. fuelwood or LPG).

Specific Objectives:

The specific objectives that were achieved during this period were:

1. Obtaining human subjects approval
2. Making significant progress toward selection of intervention stoves
3. Measuring willingness to pay for improved stoves in the study area

Significant results:

1. Stove testing results

Preliminary results show that using the Dura with a pot skirt gives the best time to 90 C for both the hot and cold start, while the Envirofit Econofire with pot skirt gave best results for hot and cold start heat transfer efficiencies as well as fuel consumption. It is important to note, though, that the Envirofit Econofire with pot skirt has been tested only once and needs more Water Boiling Tests for conclusive results. As far as usage is concerned, the Dura is fairly cumbersome and takes a long time to cool down which should be considered for user preference in Ghana. The Envirofit Econofire on the other hand is very light and was slightly difficult to maintain a simmer during the first test. If these issues are deemed important enough, it may be of interest to consider a stove such as the Greenway Jumbo that performed second best in multiple categories.

2. Willingness to pay results

Bids from the FGD auctions behaved as expected, with the WTP for the high-quality stoves exceeding the WTP for the mid/low-range model. For mid- and high-quality stoves, all bids were less than the expected retail cost of the stoves at market (neither model was widely available for sale in the region during our visit). For the low-quality stove, which was available in local markets at the time of the trip), bids were within the retail price of the stove. Results are summarized in Table 1.

3. GIS database results

The GIS database has been created. Specifically, combining the regional village location data with the REACCTING village and household locations permits the creation of spatial buffers around treated village (i.e. those receiving stoves for free in REACCTING). These buffers will be used to sample households for the present study based on their proximity to the treated REACCTING households. For example, geospatial analysis revealed that approximately half of the households tracked by regular NHRC surveying lie beyond a 2KM buffer surrounding the REACCTING study households. This is the likely buffer size to be used in our sampling stratification for the present study (potentially including buffers around market centers or major health clinics, as well). In addition, the GIS database shows the locations of LPG-using households surveyed in the REACCTING study, in relation to the location of

LPG retail centers and filling stations: This information is critical for the linked LPG study with these data, funded by NIH (see below).

Key outcomes or Other achievements:

A grant proposal for a related project, which will focus on adoption of liquefied petroleum gas (LPG) stoves in the more urban areas of our study region, was funded by the NIH Clean Cooking Implementation Science Network. In addition, the Rathmann Family Foundation provided a gift to CU to support the project's implementation and policy dissemination efforts. Both of these funding sources allow us to broaden the scope and impacts of our projects.

* **What opportunities for training and professional development has the project provided?**

Graduate students at both US collaborating universities have been involved in the project during its first year.

Timothy Molnar (CU Environmental Studies Masters Student) attended the Global Alliance for Clean Cookstoves meeting in Accra and participated in our field visit in November 2015.

Elise Mesenbring (CU Mechanical Engineering PhD Student) led stove testing activities.

David Pfotenhauer (CU Mechanical Engineering PhD Student) participated in stove testing activities.

Lee Parton (NCSU Agricultural and Resource Economics PhD Student) developed the geospatial database.

* **How have the results been disseminated to communities of interest?**

A website has been created for the project (http://sciencepolicy.colorado.edu/p3cookstoves/). This page is currently under development, and will provide a forum for disseminating project activities and results.

* **What do you plan to do during the next reporting period to accomplish the goals?**

1. Finalize selection of intervention stoves (Sept-Oct 2016)

Focus group discussions will be held in the study area to allow potential users to compare the candidate stoves and give feedback on which one(s) they would prefer. These results, as well as cost considerations and our lab testing results, will be used to make a final selection of two stove types for use in the intervention.

2. Select study sample (Sept-Oct 2016)

The geodatabase will be used along with data on social network ties collected during the endline survey of our prior project to select our peer and non-peer group clusters as well as households within these clusters (300 households total). Clusters will then be randomized into different price level treatment groups (free, "low," and "high"), using the auction results to set our "low" and "high" price levels.

3. Design baseline survey (Sept-Oct 2016)

Survey design will draw on instruments used during our prior study. New questions will be pretested by the NHRC team. Surveys will be programmed for data collection using electronic tablets using the open source ODK software.

4. Conduct baseline survey and make stove offers (Nov-Dec 2016)

Members of the CU and NCSU team will visit Navrongo in November to assist the NHRC team with interviewer training and survey launch activities. The NHRC team will complete the 300 household survey by the end of December. During the surveys, stove models will be presented and households will be given an opportunity to purchase stoves (or receive them for free) at the cluster-randomized price level.

5. Order stoves (Jan 2017)

Stoves ordered by households will be ordered from the manufacturers in January. We expect shipment to take 1-3 months based on past experience.

6. Equip stoves with monitoring equipment (Feb-May 2017)

Once stoves arrive at the NHRC, the study team will install electronic stove use monitoring equipment on a subset of stoves.

7. Deliver stoves to households and collect payments (May – June 2017)

Stoves will be delivered to recipients, and payments will be collected. Recipients will have the option to pay in installments.

8. Follow-up visits (June-Aug 2017)

A series of initial follow up visits will be made to trouble shoot initial problems encountered with stoves and collect data from the stove use monitors.

9. Personal exposure monitoring (Jan-Aug 2017)

In-home measurements of air quality and personal exposure to pollutants will be initiated prior to stove distribution and will continue on a rolling basis throughout the study period.

Supporting Files

You may upload pdf files with images, tables, charts, or other graphics in support of this section. You may upload up to 4 pdf files with a maximum file size of 5 MB each.

Supporting Files

Figure 1. Process for selection of intervention stoves

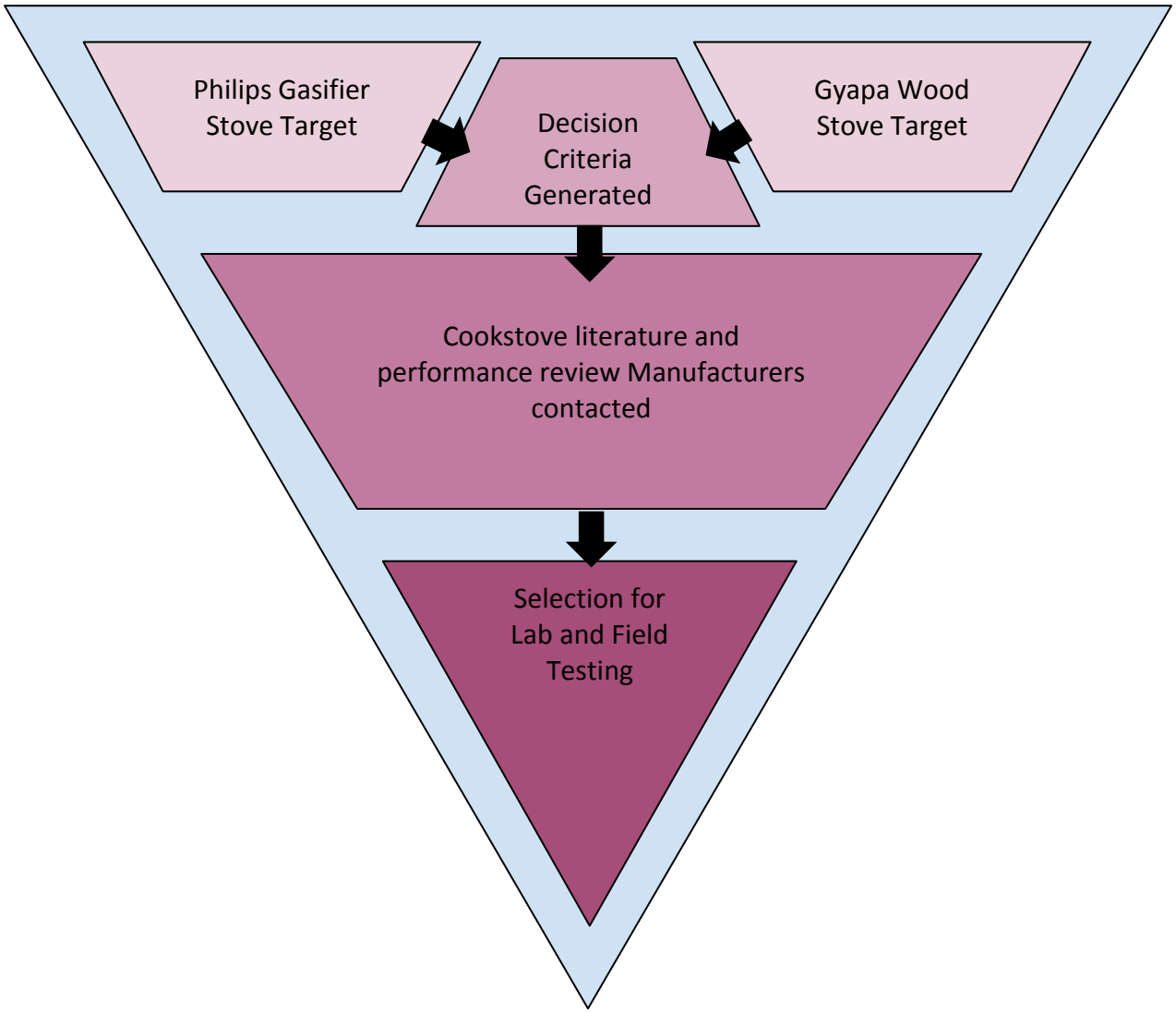

Figure 2. Photograph of stove auction focus group in the study area, November 2015

Table 1. Bid summary statistics from FGD auctions (Ghanaian cedis)

			Percentiles				
Stove model	**Mean**	**Min**	*25th*	*50th*	*75th*	**Max**	**N**
Gyapa (low/mid-quality)	13	2	2	10	15	40	31
Philips (mid/high-quality)	19	0	2	10	30	60	23
ACE (high-quality)	24	0	8	20	40	100	27

Products - What has the project produced?

(Categories:

Publications (Books, Book Chapters, Journal articles, Conference Presentations, Other Publications, Theses/Dissertations)

Technologies and Techniques

Inventions, Patents, Licenses

Websites

Other Products

Website:

Title: P3: Prices, Peers, and Perceptions: Improved Cookstove Research in Northern Ghana

URL: http://sciencepolicy.colorado.edu/p3cookstoves/

Short description of the website:

Provides an overview of our project, links to team member contact information, and a venue for dissemination of future products and results.

Participants & Other Collaborating Organizations - Who has been involved?

Have to fill out details for institution's PI and Co-PIs: months worked, contributions, funding support, etc.)

Katherine Dickinson

Nearest Person Months Worked: 3

Contribution to the Project: Project leadership and management, data collection design

Funding Support: EPA grant # RD – 8354201

Michael Hannigan

Nearest Person Months Worked: 1

Contribution to the Project: Study design and management, supervision of engineering research assistants

Funding Support: N/A

Abraham Oduro

Nearest Person Months Worked: 1

Contribution to the Project: Project direction, coordination

Funding Support: NIH Clean Cooking Implementation Science Network grant

Others: see spreadsheet.

What other organizations have been involved as partners?

North Carolina State University
Organization Type: Academic Institution
Location: Raleigh, NC
Partner's Contribution to the Project:
Collaborative Research
More Detail on Partner and Contribution: Co-PI Dr. Zachary Brown contributed to research design, participated in field visit in Nov '15 to conduct formative data collection, supervised NCSU students contributing to project.

*__What other collaborators or contacts have been involved?__

List any other people or organizations involved in the project that were not separately reported as participants or partner organizations.

NIH Clean Cooking Implementation Science Network: This organization is funding a companion project examining adoption of liquefied petroleum gas (LPG) stoves in the study area. Several aspects of this project, including the teams involved, research questions, and outreach activities, are shared across the two projects. Meetings hosted by the ISN, including a workshop in Bethesda in May 2016, provide opportunities to disseminate project results and foster new collaborations.

ORGIIS: Organisation for Indigenous Initiatives and Sustainability. This Ghanaian NGO will be involved in education, outreach, and stove maintenance activities as part of both the rural biomass stove intervention (this project) and the related LPG intervention.

CoCubed: The Colorado Cookstove Collaborative was founded by PI Dickinson to provide a forum for sharing research methods and results among various teams along Colorado's Front Range engaged in cookstove projects around the world.

Joanna Pinneo is a newly inaugurated Scripps Fellow at the University of Colorado-Boulder. In the process of developing her application for this program, she found our study team and approached us about collaborating with us during her fellowship to report on household air pollution and clean cookstove adoption dynamics in the context of our project and others.

Impact - What is the impact of the project? How has it contributed?

INSTRUCTIONS - This component will be used to describe ways in which the work, findings, and specific products of the project have had an impact during this reporting period.

For NSF purposes, include, where appropriate, discussion of data resources and the acquisition of data skills. Include the emergence of new career paths, such as data scientists, or new disciplines.

If there is nothing significant to report during this reporting period, please check "Nothing to Report" if applicable.

* **What is the impact on the development of the principal discipline(s) of the project?**

Describe how findings, results, techniques that were developed or extended, or other products from the project made an impact or are likely to make an impact on the base of knowledge, theory, and research and/or pedagogical methods in the principal disciplinary field(s) of the project.

This project demonstrated the utility of using 2nd price sealed bid auction in focus groups, combined with a detailed product demonstration, for preliminary assessment of willingness to pay (WTP) for clean cookstoves. While the economic properties of this method and similar ones are still being debated (Horowitz 2006; Berry et al. 2012), rapid appraisal of WTP via auctions will aid the NHRC in cost-effective social marketing of future health interventions and products. Based on good experience with this instrument, a similar approach for eliciting WTP (the Becker-Degroot-Marschak method) is likely to be used in the linked, NIH-funded study of LPG adoption, in order to maximize resource use, although we still plan on using standard price experiments in the NSF portion of this study due to their firmer theoretical grounding.

In addition, our collaboration with engineers is providing opportunities for novel data collection on key variables of interest to economists' study of technology adoption processes. The electronic stove use monitoring methods being developed by our engineering study team will ultimately provide objective measures of one key outcome variable: the extent to which new stoves (distributed at different price levels) are used by study participants. In addition, stove performance metrics (efficiency, emissions) will allow comparisons with users' perceptions of stove quality.

* **What is the impact on other disciplines?**

Describe how the findings, results, or techniques that were developed or improved, or other products from the project made an impact or are likely to make an impact on other disciplines.

Measuring stove use is an essential component of cookstove studies that seek to understand and quantify intervention impacts on cooking behaviors. Electronic stove use monitors (SUMs) provide a promising source of objective data on stove use, highlighting usage trends across stove types through time and space. Significant effort has been spent making SUMs effective, affordable and reliable on large scales in the field. Currently, no technology exists that fits all these criteria. Our research group has been committed to developing SUMs that come closer to meeting the needs of the cookstove research community. We have been piloting our SUMs system in the field for several months, and will ultimately publish and share this technique for wider use.

* **What is the impact on the development of human resources?**

Describe how the project made an impact or is likely to make an impact on human resource development in science, engineering, and technology.

This study is developing human resources through opportunities for education and training of several early career engineers and scientists. Engineering students Elise Mesenbring and David Pfotenhauer, as well as PRA Evan Coffey, have worked to design and carry out methods for testing different types of stoves, as well as effective technological solutions for electronic stove use monitoring. Environmental Studies graduate student Tim Molnar participated in our first field visit and gained experience with focus group design and implementation, as well as attending the Global Alliance for Clean Cookstoves annual meeting and gaining exposure to a global cadre of researchers and practitioners working on this problem.

PI Dickinson, an early career social science researcher, was promoted from Research Scientist I to Research Scientist II, due in part to the achievement of being awarded this large NSF grant.

Co-PI Brown, an early career applied economist, is undergoing his midterm tenure review in 2016/2017. This award is a significant accomplishment on his dossier and adds to his expertise and research portfolio in development economics and technology adoption. The project also provides significant experience to PhD student Lee Parton, applying his GIS skills to development economics, a new research area for him.

* **What is the impact on physical resources that form infrastructure?**

Describe ways, if any, in which the project made an impact, or is likely to make an impact, on physical resources that form infrastructure, Including physical resources such as facilities, laboratories, or instruments.

Nothing to report

* **What is the impact on institutional resources that form infrastructure?**

Describe ways, if any, in which the project made an impact, or is likely to make an impact, on institutional resources that form infrastructure.

Nothing to report

* **What is the impact on technology transfer?**

Describe ways in which the project made an impact, or is likely to make an impact, on commercial technology or public use.

Nothing to report

* **What is the impact on society beyond science and technology?**

Describe how results from the project made an impact, or are likely to make an impact, beyond the bounds of science, engineering, and the academic world.

Auction winners from the stove focus groups received improved stoves, and follow up visits indicate that they are happy with these stoves and use them frequently.

Changes/ Problems

INSTRUCTIONS -

The PI is reminded that the grantee is required to obtain prior written approval from the awarding agency grants official whenever there are significant changes in the project or its direction. See agency specific instructions for submission of these requests.

If not previously reported in writing to the agency through other mechanisms, provide the following additional information or state, "Nothing to Report", if applicable:

* Required fields

Notifications and Request

For more information on Grantee Notifications to and Requests for approval from the National Science Foundation, please visit the Notifications and Requests section in FastLane or refer to Exhibit II-1 of the Award and Administration Guide (AAG).

* **Changes in approach and reasons for change**

Nothing to report

* **Actual or Anticipated problems or delays and actions or plans to resolve them**

Nothing to report

* **Changes that have significant impact on expenditures**

Nothing to report

* **Significant changes in use or care of human subjects**

Nothing to report

* **Significant changes in use or care of vertebrate animals**

Nothing to report

* **Significant changes in use or care of biohazards**

Nothing to report