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A Guide to Optimizing Behavior Change in Fuel Efficient Stove Programs

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List of Acronyms

BDM method	Becker–DeGroot–Marschak method
CIRCODU	Centre for Integrated Research and Community Development Uganda
CLO	Community Liaison Officer
FPP	Focal Point Person
ICS	Improved cookstove
KPT	Kitchen Performance Testing
NGO	Non-governmental organization
PM	Particulate matter
RCT	Randomized Controlled Trial
SUM	Stove Usage Monitor
UCB	University of California at Berkeley
UCB-PATS	UCB Particulate and Temperature Sensors
USAID	United States Agency for International Development
TRAction	Translating Research into Action
WTP	Willingness to Pay

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1. Introduction

This guide was produced as a result of Impact Carbon's USAID's TRAction (Translating Research into Action) funded study to identify behavioral determinants of improved cookstove (ICS) acquisition and ongoing usage. The research was designed to identify program strategies that are replicable in developing countries with high burdens of disease from indoor air pollution (IAP). The research, funded by USAID's TRAction Project, was conducted by Impact Carbon in partnership with University of California, Berkeley (UCB); the Uganda-based Center for Integrated Research and Community Development (CIRCODU); and Cornell University's Atkinson Center for a Sustainable Future. The study lasted for two years (from 2011 to 2013) and was carried out in Mbarara Uganda involving approximately 4,500 households. Although other experiences of Impact Carbon contribute, the methods and findings of the study are the basis for the guide. This guide gives recommendations in the following areas:

- **Feasibility phase,** providing guidance on how to determine the best area for the project; who to work with; and what ICS to use;
- **Logistics,** covering transporting ICSs; hiring, training, housing, and paying staff; designing survey instruments; collecting and organizing data; organizing sales meetings; and collecting payments;
- **Willingness to pay and marketing messages**, focusing on the importance and impact of marketing; assessing willingness to pay; and testing marketing messages;
- **Utilizing innovate sales offers to optimize adoption**;
- **Leveraging peer effects**;
- **Optimizing usage measurement methods**;
- **Feedback on ICS**.

The goal of each section is to offer advice on the key elements necessary for a successful stove project. Implementers may choose to view only certain sections based on specific questions or read the entire guide in order to get an overview of the components of a stove project.

For questions regarding this guide or Impact Carbon's TRAction funded study, please email info@impactcarbon.org or visit www.impactcarbon.org.

2. Feasibility phase

2.1 What is the purpose of a feasibility study?

There are many factors that should be considered when planning an improved cookstove (ICS) project. Before beginning a project, implementers must determine how and where to best carry out a cookstove project. The following recommendations increase the likelihood of a successful stove project:

1. Select a region appropriate for the intervention considering local cooking practices, wealth, disposable income, etc.;
2. Determine who to work with in the chosen region (i.e., bring in one's own team or hire locals);
3. Test different ICSs and evaluate the best choice for households within the study zone;
4. Evaluate and understand household practices, patterns, and preferences related to cooking, as well as how
5. improved stoves fit in households priorities;
6. Design training on how to use the chosen ICS;
7. Determine how to reduce the use of traditional stoves;
8. Consider the number of cooking points households commonly use during each meal;
9. Design and test the efficacy of different marketing messages related to ICS;
10. Evaluate lessons learned from other stove projects;
11. If applicable, design protocol for measuring stove usage.

2.2 How to conduct a feasibility study

2.2.1 How to determine the best region for the ICS project

The region chosen for a stove project can have a significant effect on the success of the project. When deciding what area to conduct the project in, implementers must consider many factors. Key criteria include:

- Percent of households who cook with wood or charcoal burning stoves (depending on target population): In order to have high sales and usage of ICS, the vast majority of targeted households must be using the appropriate fuel as their primary fuel.

- Percent of users that buy the relevant ICS fuel type: Households that buy fuel should be able to realize direct monetary savings from using an ICS: given enough time, the stove will pay for itself in savings. Selecting a project area with a high percentage of fuel purchasers can be beneficial for sales.

- Number of hours per week spent gathering wood: Households that spend a significant amount of time collecting wood can realize significant time savings from the purchase and use of an ICS. If wood is plentiful to gather, then households would spend little time gathering fuel and would therefore be less motivated to purchase an ICS.

- Presence of an ongoing or recent ICS initiative in the region: Working in an area with an ongoing or recent ICS program can complicate a new stove program. If the previous program has been successful and many households already have working ICSs, then there is less need for an

additional ICS program and resources may be better allocated elsewhere. If the previous program was unsuccessful or was discontinued and many households have ICSs that are broken, they may distrust ICS products and will be less likely to purchase a new ICS. Moreover, if a previous ICS program delivered stoves for free or for a heavily subsidized price, it is possible that household will have distorted perceptions of the value of future ICSs or may be reluctant to purchase an ICS. In these instances, it is best to avoid areas where there is an ongoing or recent ICS program. On the other hand, a successful prior stove program may create an environment where households are eager to purchase ICSs. Therefore, if there has been a prior study/program implemented in the selected region, the effect of that should be evaluated.

- Percent of households that cook indoors: Households that cook primarily indoors have a greater need to reduce smoke. Selecting a region with a high percentage of households that cook indoors presents an opportunity to achieve a greater impact in reducing smoke exposure. Also, there is a possibility that households will be willing to pay more for the stove if they cook indoors and dislike smoke exposure. In the TRAction study, households often mentioned that they disliked the smoke and that it caused their eyes to burn and caused them to cough.

- Accessibility of the region: It is important to consider the level of difficulty associated with reaching target households. For example, if roads are extremely poor or prone to flooding, then the implementer needs to take that into consideration when deciding which region to work in and how to access it.

- Local languages spoken: For every language spoken in the stove project region, there must be staff members who speak that language in order to communicate with each interested household.

- Sufficient population size/potential market size given goals: An assessment should identify whether or not there is an adequate market for the ICS, the degree of market saturation, customer interest and awareness, and whether or not there is sufficient willingness to pay (in the event that this is not the case, there will need to be adequate consumer financing mechanisms in place to facilitate adoption).

Ideally the above criteria would be evaluated based on official data, but in rural, poor regions official data is often absent. As an alternative, one can meet with local government officials and ask them to estimate each criterion.

2.2.2 How to determine who to work with in the selected region

Depending on the size of the organization, budget, and longevity of the stove program it may be best to transport staff members to the project site, to hire people who live in the project site, or a combination of the two. If staff members are transported to the project site, costs of transportation, per diem, and housing should be considered. If one hires people who live in the project site, it is important to consider costs of training and ensure that their quality matches that of current staff members. Transporting some seasoned staff members and then training additional people that live in the project site may be an optimal balance. Implementers can also hire local people to oversee different portions of the project. Local government officials or prominent community members can be helpful to identify local people that would work well given program objectives.

Given the complexities of the TRAction study, Impact Carbon transported a skilled research team from Kampala to Mbarara to carry out the study. Using local government officials, the project staff also identified and hired local people to mobilize households for group meetings for stove sales and to collect time payments after households have purchased stoves. The combination of a skilled research team and local involvement facilitated the project's success.

2.2.3 How to determine which ICS to use

When deciding which ICS to use, one should first gain an understanding of users' cooking patterns, preferences, and needs. This can be accomplished through focus groups and household visits. Then, consider the available options and select which one(s) best fits the following criteria:

- Does the ICS satisfy the cooking needs of the house?
    - Is it the right size for the majority of households given the amount they cook?
    - Does it fit the containers they use to cook food?
    - Can it cook the various dishes each household cooks (i.e., If most households make tortillas can you cook tortillas on it?)?
- How similar are the ICS's cooking methods compared to traditional cooking methods?
    - If there are significant differences, what training is required and how should this training be delivered?
    - If fuel must be prepared in a different way, how likely are households to be willing to prepare it?
    - If an alternative fuel is required, how prevalent is the new fuel? How easy is it to access?
- Are there new costs associated with the ICS when compared with traditional cooking methods?
    - If a new fuel is required, how much does it cost for households to purchase?
    - How do new fuel costs compare to current fuel costs?
    - Are there costs associated with maintenance or repair?
- What are the positive effects of the stove?
    - How fuel-efficient is the ICS?
    - Does the ICS reduce smoke or PM concentrations?
- What is the cost of the ICS?
    - What is the cost to purchase the ICS from the manufacturer?
    - What are the associated domestic and international (if applicable) transportation costs?
    - What margin do retailers need to make to be able to justify carrying the product?
    - Some basic WTP assessments and feasibility tests need to be conducted to answer these questions.
- How durable is the ICS?
    - Given the local cooking practices, how long is the ICS expected to last? Do certain components need to be replaced more frequently than others?
    - What are the costs associated with fixing the ICS? What maintenance options are available and how can after-care service be provided?
    - Will there be spare parts available to households?
    - Will households have access to purchase additional ICSs when their first ICS deteriorates?

After evaluating the available ICSs in relation to the above criteria, it is important to field test the top ICS candidates. The TRAction study, for example, selected four ICS and tested them through focus groups

and in-home visits. Each participant was asked to rank the order based on preference for the four ICSs. Stove selection was based on the participants' ranking.

The study also leveraged this early consumer research to gain valuable customer insights that were incorporated into marketing activities, stove demonstrations, and end user training. These findings enabled the team to better target sales efforts and identify households most likely to succeed with the ICS (e.g., households of optimal size).

3. Logistics of a cookstove project

3.1 How to best transport stoves

Transportation of ICS across rural roads in developing countries can be both challenging and expensive. For example, transport across bumpy roads for long distances can easily damage an ICS or one of its fragile components. Whilst conducting the TRAction study, which used a stove with a fragile clay insert, the team carefully wrapped each piece to ensure successful transport. This minimized breakages, though extra pieces were ordered to account for any instances of broken clay inserts.

Cost of transportation must also be considered, as this can contribute significantly to program costs and can often result in a more expensive product. The TRAction project team found that it was cheapest to transport large quantities of cookstoves by renting or purchasing vehicles to transport cookstoves from the point of importation to the project site warehouse.

From the warehouse point, depending on the program's sales strategy, stoves can be further transported to rural households either in mass via renting or purchasing a vehicle, or in small quantities using local vehicles, such as motorcycles. In Uganda, for example, there are motorcycle taxis throughout all rural areas that can be used as an inexpensive mode of transportation for 1-10 cookstoves (depending on the size of the cookstove). Goods in small quantities can also be cheaply transported by using vans or buses that also transport people. For a small fee, goods can be stored on these vehicles and delivered to town centers throughout the country. Finally, Impact Carbon's TRAction research project was able to decrease some distribution costs by organizing end consumers in a central location, at which point a customer would pick up the stove and take it back to his or her house.

3.2 Hiring, training, housing, and paying staff

In order to implement a successful project, it is critical to properly train staff. The following factors should be considered:

- All staff must have a strong understanding of the overall purpose and goals of the project, benefits of the ICS, project design, etc.;
- Key staff should be rigorously trained in all communication with end consumers and in understanding all questionnaires that they will enumerate and marketing messages that they will deliver;
- Key staff should be proficient in use of all project related technology (e.g., smartphones used to collect data);

- Key staff should field test all questionnaires and provide feedback before enumerating the final surveys. If necessary, sufficient time should be allocated to translate the survey into local languages;
- If questionnaires and messages are translated into different languages, it is key that the meaning is retained;
- Project managers should identify and appoint qualified and experienced point people to manage important areas, including production, inventory, procurement, sales, finance, and administration. These employees should be empowered to create training manuals, provide trainings, and identify and address ongoing training needs.
- If the goal of the project is to maximize sales of ICSs, then commission based pay can incentivize salespeople.

It is important to determine the logistics of transporting and housing staff. If staff members are hired that live in the area of the study/project, then individuals may be able to transport themselves to and from the project site as well as provide their own housing. However, if staff members are hired from a different area, then transportation and housing may need to be provided.

When conducting the TRAction study, based in Mbarara, Impact Carbon collaborated with a partner organization (CIRCODU), based in Kampala. The project transported 17 of their staff members from Kampala to Mbarara, approximately a four hour drive, to carry out the study. To transport staff cost-effectively, the project hired drivers who facilitated transportation from Kampala to Mbarara, as well as within the Mbarara region. Lodging costs were significantly reduced by renting a house that accommodated all staff members, and by hiring a local cook to prepare meals for the team. If the ICS project is expected to continue for a long period (the TRAction study had a fixed term timeline), it is important to build a strong local presence.

Working with local government officials in Mbarara, Impact Carbon identified and hired local focal point persons (FPPs) to mobilize households for group meetings for stove sales and to collect time payments after households purchased stoves. The project paid the FPPs a flat rate for organizing group meetings and then paid them on a commission basis for collecting stove payments. This helped to reduce costs and increase presence throughout the rural communities of the study. Impact Carbon has since incorporated this method into the implementation other projects and has found it to be successful.

3.3 Survey instruments

High quality survey design requires attention to content, structure, and a consideration of how the survey will be enumerated. For content, implementers must determine information gathering objectives. Possible areas of focus include:

- Understanding household characteristics: Number of people living in the house, gender and age of each person, occupations of each person, marital status, and education of each person;

- Understanding cooking patterns: Commonly cooked foods, size of pots usually used, meal preparation (including preparing two meals together), type(s) of stove used, type of fuel used, prevalence of purchasing and/or gathering fuel, materials used to start a fire, and number of people usually cooked for;

- Understanding household wealth/liquidity: Commodities the household owns (e.g., mobile phone, radio, television, motorcycle, car, animals that signify some wealth, having a paved floor in the house, or having a metallic roof).

Additional attention should be given to the survey structure. The survey should ask questions in a logical way that creates a flowing conversation. As far as possible, it is best to have multiple choice questions instead of fill in the blank questions to simplify data analysis. In order to ensure that the multiple choice options cover 95% of responses, implementers should field test the surveys and determine all common responses. If questions are asked that involve sensitive information, enumerators should be trained on how to handle uncomfortable respondents and the survey should allow for enumerator comments if it seems the respondent is providing false information.

Surveys can be enumerated via paper surveys or electronic surveys. If budget is available, electronic surveys can increase efficiency, reduce error in data cleaning, and enable easier identification of errors in the survey design. The TRAction study used smartphones and electronic survey software, Episurveyor, to enumerate surveys. Data was uploaded daily and any errors were caught early. It was also easy to make additional changes to the survey design as more insight was gained. In addition, it is important to give careful attention to skip patterns when programming an electronic survey. For example, if one asks how many children a respondent has, if he/she responds with zero then the electronic survey should not next ask “What are the ages of your children?” Without proper skip patterns, responses to questions can contradict each other resulting in difficult data analysis.

3.4 Data collection and organization

Procedures for collecting and organizing data are necessary for quality checking and optimizing data analysis. These procedures should be developed before starting the project. It is useful to have a team member tasked with checking initial data as it is reported in order to quickly identify issues and amend the survey as needed. The TRAction study gathered the majority of data using smartphones, although data such as attendance sheets was gathered using paper surveys. Separately, inventory of stoves and meeting attendance were checked using a paper survey that was then reported in an excel file. Different team members were responsible for checking each type of data to ensure correct data collection.

3.5 Organizing sales meetings

In rural areas where houses are spread far apart, sales meetings may be an efficient way to sell ICSs to many people. The TRAction study hired one full-time staff, a community liaison officer (CLO), to train and work with FPPs in each parish responsible for gathering people together for a sales meeting. The CLO provided training on the benefits of the stove and the objectives of the meeting including targets for numbers of people gathered (the expectation was 60 people). The FPPs then went throughout their communities publicizing the date, time, and location of the sales meeting. On the day of the sales meeting, the team set up a large tent in a pre-determined and highly visible location. Staff members, drivers, CLOs and community members would circulate throughout the communities to gather more people.

3.6 Collection of time payments

With a traditional sales offer, customers are expected to pay the full product price upfront without any knowledge of its benefits and without any experience using it. Poor households who have little cash and lack experience with new technology may be unable or unwilling to adopt. The TRAction study showed that these barriers can be addressed with a novel sales offer that combines a free trial, time payments, and the right to return the product. This novel sales offer increased uptake 12-fold when compared to the traditional sales offer. While time payments prove essential to increasing demand, the collection of payment can be burdensome or expensive. As a result, best practices must be developed for optimal payment collection.

Working with local government officials during the TRAction study, Impact Carbon identified FPPs to first organize the sales meetings and then assume responsibility for collecting payment installments. This helped to generate enthusiasm for the project, maximize sales, and reduce costs payment collection costs. While FPPs were motivated about the project, repayment rates were initially lower than expected. Once FPPs were given a 10% commission, repayment collections rose significantly. This method resulted in a 99% repayment rate.

It is advisable to collect repayments from the FPPs (or similarly appointed individuals) frequently, and to minimize the amount of time with which the community members are expected to possess the money. The TRAction project collected money from the FPPs on a weekly basis, and then paid them commission after they completed collection of all payments for each household. Different options can also be experimented with to determine the optimal number and frequency of payments (e.g. two payments in two week intervals and/or using mobile money for the FPPs to transfer funds).

Although the TRAction research project did not utilize mobile money, it can likely optimize time payment collection. It is possible individual households can transfer payments via mobile money; alternatively, a payment collector could continue to manage payment collection with cash and then transfer the total back to the project implementers on a regular basis. Success may vary depending on the prevalence and awareness of mobile money, and may also depend on consumers' willingness to pay the transaction fees. Impact Carbon has experimented with mobile money collection and has found success in leveraging centralized community contacts.

Incentivizing local shopkeepers to sell ICSs via the novel sales offer may also prove a viable low-cost mechanism, though specific incentives have not yet been tested. Possibilities include offering the shopkeeper a no risk or low risk financing arrangement, where the implementer loans cookstoves to the shopkeeper and requires payment only after the shopkeeper receives payments from customers.

4. Assessing willingness to pay and marketing messages

4.1 Importance and impact of marketing

Creating awareness and engaging communities is vital to a successful cookstove rollout. There are two areas that are critical to successful communications and engagement strategies: (1) the message and (2) the medium. In order to engage people effectively an organization needs to create a clear, meaningful

message that will be understood and resonate with their target customers. Input from the market assessment around purchasing drivers and the values of a product should be used to craft simple marketing messages that will convey a relative value proposition to the end user. In addition to the value proposition, this message should also convey educational and health aspects to the user. It is important to prioritize the primary and secondary messaging internally to reference as an organization launches varying marketing campaigns. Often organizations will want to include as many benefits as possible into their messaging, however, the message should be focused, not broad. For example, end users will often consider money savings as their top priority. Therefore, crafting a core message around savings, despite the other benefits, is critical to communications. The Social Marketplace, a tool sponsored by Impact Carbon, has collected a number of sample communication materials in their Resource Center[1].

After the core message is crafted this can be communicated to the target population. Grass roots marketing efforts, which deeply engage the community, have been proven to be extremely effective at consumer sensitization and sales. Studies around this can be found in Hystra's report[2] involving marketing new devices to end users at the bottom of the pyramid (BoP).

Examples of this type of engagement are local demonstrations with community leaders and product 'road shows'. Impact Carbon has found that engaging key influencers within the community for sales demonstrations and messaging is often more effective than leveraging official local representatives. Key influencers are people within the community that are heavily engaged in local activities, whom others know and trust.

It is also critical to engage local government as much as possible. They can often support messaging and education initiatives at the local and/or national level. In addition, institutional networks such as schools and health centers can be engaged to share health messages around efficient cookstove use for their community. Implementers should work with these networks to supply them with marketing and educational collateral to distribute on behalf of the organization. All material should have clear contact information so the audience can learn more if interested.

After the initial marketing strategy is designed, organizations should ensure that marketing messaging and tactics are continually updated and optimized by a) monitoring customer feedback b) by measuring the return on investment of each campaign by assessing the cost of sales vs. total revenue; and c) monitoring distributor and retailer feedback on the efficacy and implementation costs of each campaign in different locations. To do this, the cost of each sales trip should be recorded, including the time and resources committed as compared to the revenue from each sales initiative. This information enables organizations to focus on the most cost effective sales campaigns. Continuous analytics and performance monitoring are critical to ensure successful marketing.

4.2 Assessing willingness to pay

Different techniques can be used to measure willingness to pay (WTP). It is important to remember that these assessments, while useful, only provide a range of WTP and may not always be accurate. It should

[1] http://thesocialmarketplace.org/resource-center/.
[2] http://hystra.com/open-source-reports/

be expected in auctions, for example, that people will tend to underbid for the product, and that actual WTP may be higher than the reported WTP. Techniques to measure WTP including the following:

- Test sales at different price points: This method involves selling stoves in different locations at different price points (need to ensure end consumers do not have access to locations with different price points). This should give the most accurate information on WTP, but depending on how extensively this method is used, lower price points may sour the market;

- Sealed-bid, second-price auction: All participants are asked their bid in private and the highest bid wins, but pays the amount of the second highest bid. This method can be done using many participants, but participants are less likely to reveal their true WTP, especially in a bargaining culture;

- BDM (Becker-DeGroot-Marschak) method: In this method, the implementer will have a price written down in a sealed envelope. The participant will be asked his/her WTP. Then the envelope will be opened and the price revealed. If the WTP is at or above the envelope price, the participant can purchase the ICS for the envelope price. This method requires more time as it must be conducted with individual participants, but participants may be more likely to reveal their WTP than in the sealed-bid second price auction.

In the TRAction study, 36 parishes were selected in rural Uganda to participate in a sealed-bid second-price auction. Each parish covered a handful of villages, totaling approximately 5,000 to 6,500 residents. In each of the 36 parishes, focal point persons (FPPs) were hired to publicize the upcoming visit. At each meeting, participants were separated into four groups, each of which received a different marketing message. The team then conducted a sealed-bid second-price auction and asked households to bid on purchasing a stove by privately writing down and submitting their willingness to pay. The team received interesting data, but discovered that reported WTP was far lower than actual WTP. In a bargaining culture such as Uganda, it is difficult to incentivize people to reveal their actual WTP, which may explain why households bid far below their actual WTP. For example, the WTP auction showed that only 2.25% bid USD $16 or more, but during the actual sales process more than twice as many (5%) bought the stove at a sales price of USD $16.

4.3 Testing marketing messages

The TRAction study used WTP assessments to simultaneously test marketing messages. Two messages were tested, one related to health impacts of burning wood and another related to how the stove can save time and money. After participants were randomly divided into four groups, each group was chosen to receive a marketing message of health benefits, time and money saving benefits, both, or none. All marketing messages included a stove demonstration, a marketing message, a detailed explanation of the second price auction, and collection of participants' bids in each auction.

The study found that marketing messages did not increase WTP, as all the groups had approximately the same average bids. Although the marketing messages did not increase WTP, it is possible that marketing messages will still increase uptake (i.e., percent willing to buy given a fixed price). It may also be worthwhile to test different methods of delivering marketing messages (e.g., SMS texting, community engagement, radio/speaker advertisement) to see if different methods increase WTP or uptake.

The research team conducted a short survey about demand determinants, including household size, previous technology adoption behavior, cooking practices, whether wood for cooking was collected or purchased, whether households earn their own income, durable good ownership, and intra-household bargaining power. Of the household characteristics the study only found one that had a statistically significant effect on WTP—if the respondent was female, WTP decreased by 25%. Involving husbands in the decision-making process of purchasing an ICS may help maximize sales.

5. Utilizing innovative sales offers to increase adoption

A new sales offer must overcome barriers that prevent households from adopting an ICS under traditional sales offers. The TRAction project considered common barriers for potential ICS customers:

- Evidence exists that many consumers in poor nations face liquidity constraints and present bias and thus find it difficult to come up with the entire purchase price of a durable good in one lump sum. For such consumers, time payments can be a solution;

- Consumers are subject to many marketing messages and most learn that not all salespeople can be trusted. Many consumers may, therefore, not believe the claimed benefits of the ICS. For such consumers, a free trial can be a signal of credibility. The free trial period gives consumers a chance to experience the benefits of the ICS before committing to purchasing it.

The study determined that demand for a $16 stove increased 12 fold when consumers were offered a free trial and four weekly payments as opposed to a traditional offer of full upfront payment. These findings corroborate with the results from a previous study by Professor David Levine (Levine, Beltramo, Blalock, & Cotterman, 2013), which isolated a free trial and time payments—both show significant increases in uptake. These findings suggest that a combination of free trials with time payments can best increase uptake rates.

Some modification of this novel offer will likely still result in increased sales. For a free trial, one possible modification would include a designated “trial product”. Using an ICS as an example, one could give out a “trial stove” to one household, and once that household decides whether or not to buy a stove, the “trial stove” is given to another household. This may reduce costs from returns (the TRAction study had an 8.2% return rate after the free trial). For time payment collections, reducing the number of payments may reduce the cost of payment collection. This would need to be balanced with a potential decrease in uptake.

The TRAction project found success in paying select community members a 10% commission to collect repayments. Upon collecting 100% of the time payments for any particular customer, FPPs received a 10% commission for the retail price of the stove. This system resulted in 99% of households completing the payments. It is also possible that collecting payments directly from households via mobile money would reduce collection costs as well. Impact Carbon has tested this novel sales offer with other products, such as water filters, and found a similar increase in uptake (10 times that of the traditional sales offer).

6. Leveraging peer effects

If implementers are able to motivate prominent community members who can sway public opinion to adopt an ICS, it may result in increasing other community members' interests in purchasing an ICS. The TRAction study did not target any specific community members, but tested if households owning an ICS resulted in increasing the likelihood their neighbors would like to purchase an ICS. The study examined neighbors of people who have ordered an ICS, but where some have randomly been allocated to receive the new stove first (early) and others to receive the new stove one month later (late). When the early group had owned their new stove for three weeks and the late group had not yet received their new stove, neighbors of early and late group households were visited and offered to purchase an ICS. The study found that neighbors of the early group were no more likely than neighbors of the late group to purchase a stove. The results may have been confounded by word-of-mouth or neighbors having relationships with households from both the early and late groups.

7. Optimizing usage measurements methods

To understand the effects of new stoves, it is not enough to measure purchase rates. It is crucial to measure both use of the new stove *and* any reduction in use of traditional stoves (Miller & Mobarak, 2011; Ruiz-Mercado, Masera, Zamora, & Smith, 2011). Many owners of new stoves continue to use old stoves and fuels. Such stove "stacking" can minimize reductions in fuel use and household air pollution. Many studies have highlighted the complexities of measuring cooking events and numerous methods have been developed to measure them.

Some studies have used stove usage monitors (SUMs) to record temperatures of stoves to determine stove usage (Ruiz-Mercado, Canuz, Walker, & Smith, 2013; Ruiz-Mercado, Lam, Canuz, Davila, & Smith, 2008). SUMs readings can be difficult to interpret because readings vary based on distance from the heat source. For traditional cooking methods it is particularly difficult to have measurements with consistent distances from the heat source. Also, SUMs become damaged when exposed to high temperatures. This damage is particularly problematic if damaged SUMs are non-random; for example, when placed in homes that cook more than average.

Physical observations are another common measurement for improved cookstove studies. They have been used to verify fuel supply, stove use, and food preparation (Wallmo, 1996).

Although not a common measurement used in improved cookstove studies, food diaries have been used in other studies as a useful tool to understand populations' diets (Krall & Dwyer, 1987; Prentice, 2003). Food diaries can be inaccurate because of recall bias and experimenter demand effects (if respondents over-report use of stoves that the experimenter is interested in). Food diaries also do not directly measure the duration of cooking (although they can include proxies such as what dishes were cooked).

The Kitchen Performance Test (KPT) is the principal field–based procedure to demonstrate the effect of stove interventions on household fuel consumption. The KPT includes measuring wood available for cooking over the next 24 hours and then returning a day later and measuring the remaining wood. Leading researchers advise the KPT testing period should be for at least three days, avoiding weekends and holidays (Smith, *et al.*, 2007). Although the KPT is a useful tool to measure fuel consumption, it is

imperfect. The final fuel weighed may include additional wood that was not in the original pile. Alternatively, the family may have used some wood in the original pile for a purpose other than their cooking (e.g., to lend to a neighbor). Wood also may get wet between the initial and final weighing.

Particulate Matter (PM) monitors have been used to measure concentrations of particles in wood smoke from cooking that have negative health effects (McCracken et al., 2007; Smith et al., 2010). PM monitor data is difficult to interpret as PM monitors are not standardized and the relationship of cooking to PM concentrations depends on stove and fuel type, type of cooking (high or low temperature, smoldering wood, etc.), airflow in the kitchen, and other factors.

Water boiling tests (WBTs) and controlled cooking test (CCTs) have been used in cookstove studies. These tests have proven to be more useful for measuring stove efficiency in the laboratory rather than measuring stove usage by households in the field (Smith et al., 2007).

The TRAction study compared the following methods:

- Stove Usage Monitors (SUMs) that continuously log stove temperature;
- Physical observations of cooking;
- Food diaries (that record meals cooked, stoves used, and number of people cooked for);
- Kitchen Performance Tests that weigh fuels before and after cooking;
- Particulate Matter monitors which measure indoor air pollution.

To date, the research team has only analyzed the baseline data (collected prior to ICS introduction). The team found statistically significant positive correlations between almost all pairs of the following: time spent cooking (based on a predictive logistic regression using logged temperature data and physical observations), number of people cooked for, kilograms of wood used, and particulate matter concentrations. While the correlations are positive, the explanatory power of each regression is low. The modest explanatory power of each pairing emphasizes the importance of using multiple techniques to measure cooking events in order to increase confidence in findings. Although results are preliminary, the team has found that SUMs give much more accurate readings on ICSs than they do on traditional three-stone fires.

8. Feedback on the improved cookstove from participants

In the TRAction study, the Envirofit G-3300 was distributed to more than 1,100 households over an eight month period. Additional household feedback and data was collected on 268 households, through multiple individual visits to 168 households and 10 focus groups of about 10 women each over a six month period. Overall, the Envirofit G-3300 was well received by households. For virtually all households, the only alternatives to the Envirofit were a three-stone fire (90%+ only alternative) and a mud stove (<10%), both of which produce much more smoke and burn wood much less efficiently than the Envirofit. Households recognize these negative aspects of traditional stoves and thus are eager to adopt an improved cookstove.

Households liked the following aspects of the Envirofit G-3300 stove:

- The stove looks modern and is attractive;
- The stove lights quickly and cooks food quickly (of the appropriate size pots);

- The stove produces less smoke;
- The stove saves fuel;
- The stove is portable.

However, despite the readiness of many households to purchase the Envirofit stove, there are some major issues that affect long-term use and impede complete replacement of traditional stoves. Issues include:

- The stove is too small for many households;
- The stove does not allow for cooking two pots concurrently[3];
- The stove requires chopping small pieces of wood and frequent attention;
- The stove is not sturdy enough for heavy stirring[4];
- The stove does not retain heat for a long period.

The Envirofit stove is too small to cook the main portions of each meal for many, if not the majority of households in Uganda. Although the Envirofit is supposed to cook for 6-8 people, many Ugandan households cook portions that are too large for the Envirofit G-3300. This results in large households (specifically, those that feed more than 6 people) only using the Envirofit to cook side dishes, sauces, milk tea, and to boil water, while continuing to use the three-stone fire to cook the main portions of each meal. This parallel cooking lessens the stove's impact on decreasing smoke and reducing fuel consumption. The Envirofit needs to not only be larger, but also should have the ability to accommodate cooking side dishes or sauces concurrently.

When using the three-stone fire, users are able to cook using a large piece of wood and leave the stove unmonitored for an hour or so, freeing up time to do other tasks. The Envirofit stove, however, requires smaller pieces of wood, which have to be added frequently and require more attention. When households have little time to cook, they do not have time to chop or prepare wood; thus, they use the three-stone fire. Increasing the size of the Envirofit stove might also allow for bigger pieces of wood and require less frequent monitoring, although some of the thermal efficiency improvements and emissions reductions seen with the stove are due to using fuel of a smaller diameter. Households also found it difficult to use wet wood in the Envirofit. This is a significant problem because it rains much of the year, making it difficult to acquire dry wood during that time.

Several common foods in Uganda require strong stirring, called "mingling." Three-stone fires can nestle a round-bottomed pot, permitting the cook to stir with both hands. In contrast, that vigorous stirring tips over an Envirofit; the cook must therefore use one hand to hold the pot, which reduces the force of stirring. Creating a steadier bottom or a skirt, perhaps coupled with a holder than can nestle a round-bottomed container, might stabilize the new stove.

The Envirofit heats up quickly, which is an important advantage. It also cools quickly, which is an important disadvantage. Many households cook food for lunch and then keep leftovers warm on coals on the three-stone fire to eat at dinner. Given that the Envirofit cools quickly, it is not able to serve this function of keeping food warm for long periods of time.

[3] The Envirofit Company has an accessory (the G3355) that works with the stove to allow for a second cooking point for side dishes, although The TRAction study did not use it.

[4] The Envirofit Company has since designed a model (the M5000) that allows for better stability and heavy stirring.

It is also difficult to light the stove for Ugandans who are used to the three-stone fire. The team found that the Envirofit was best lit by lighting a piece of paper or dry grass placed through the front, then placing small pieces of wood through the top of the stove. The study held additional training on best practices, which helped households learn to light the stove easily.

The Envirofit G-3300 is likely to sell well in Uganda and other similar countries. If these issues are addressed the stove will sell much better, have the potential to fully replace traditional cookstoves, and have much more significant impacts on households' health and on the environment.

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