MARKETING THE ACE1 IMPROVED COOKSTOVE IN NORTHERN GHANA: LESSONS LEARNED FROM THE PRICES, PEERS, AND PERCEPTIONS (P3) STUDY

P3 STUDY TEAM:

NAVRONGO HEALTH RESEARCH CENTRE

ABRAHAM REXFORD ODURO, MAXWELL DALABA, REX ALIGIRIA, DESMOND AGAO, ALI MORO

ORGANIZATION FOR INDIGENOUS INITIATIVES AND SUSTAINABILITY GHANA (ORGIIS)

JULIUS AWAREGYA, CLIFFORD AMOAH, JOHN BOSCO ABURIYA

UNIVERSITY OF COLORADO

KATHERINE DICKINSON, MICHAEL HANNIGAN, EVAN COFFEY, ELISE MESENBRING, NATALIE BANACOS

NORTH CAROLINA STATE UNIVERSITY

ZACHARY BROWN, MICHAEL JONES

October 30, 2019

Study Design and Objectives

The Prices, Peers, and Perceptions (P3) project was carried out in the Kassena-Nankana Districts of Northern Ghana from 2017-2018 to explore strategies for household energy transitions: getting cleaner stoves into homes and getting household members to use them long-term. This work builds on a prior study in the region called Research on Emissions, Air Quality, Climate and Cooking Technologies in Northern Ghana (REACCTING), in which participants received free improved biomass stoves [1]. To investigate the interactive effects of peers, prices and perceptions on demand for cookstoves in the subsequent P3 study, participants with and without social connections to the REACCTING participants were offered the opportunity to buy stoves at different prices [2]. The two types of stoves used in the P3 study were the ACE1 forced draft stove and the Greenway Jumbo rocket stove. This report summarizes the P3 study's key findings related specifically to the ACE1 stove, including measures of willingness to pay and repayment rates, stove maintenance and repair issues, and impacts on electricity access and fuel use.

Willingness to Pay

Stove Price Levels and Randomization

To design our intervention and maximize our ability to detect price and peer effects on stove choice, we needed prior data on willingness to pay for the Jumbo and ACE stove models. As a starting point, we used data from the five stove auctions that we conducted in November 2015. The Gyapa stove (similar to the Jumbo) was sold in two of these auctions, the ACE stove was sold in two auctions, and a Philips stove (similar to the ACE) was sold in the final auction. Results from these auctions are shown in **Table 1**. The mean bids for the higher quality stoves were 48% (Philips) and 84% (ACE) higher than for the Gyapa (**Table 1**). A quarter of participants in the higher-quality stove auctions bid at least 30 cedis, whereas only 5% of participants in the lower-quality stove auctions bid at least this amount.

Table 1: Bid information from stove auctions

Stove	Number of Bids	Bids			
		Ghanian cedis		US Dollars	
		Mean	Std. Dev.	Mean	Std. Dev.
Gyapa	31	13.10	8.19	$2.98	$1.86
Philips	23	19.35	16.88	$4.40	$3.84
ACE	27	24.04	25.25	$5.46	$5.74

Based on these results, we generated an initial set of prices for the two types of stoves: GHC 0 to 30 for the Jumbo and GHC 0 to 60 for the ACE. After launching the sales experiment in the first four clusters in the Northern region of the study area, we observed higher than expected stove demand. We therefore redesigned the price treatments for the remaining three regions based on this higher observed demand. For the final experiment, Jumbo stoves were sold for prices ranging from GHC 0 to 120 (~US$0 to $27), while the ACE was sold for GHC 15 to 240 (~US$3.50 to $55). This encompasses a range of prices from free distribution to near 100% of the cost of the stoves (US$30 for the Jumbo and $85 for the ACE). Stove sales meetings were completed with all study participants between March and May of 2017.

Stove Orders and Demand Estimates

Stove order tallies are presented in **Table 2**.

Table 2: Stove orders by peer and non-peer groups and region

	Peer			Non-Peer		
Stove Order:	**North**	**Other regions**	**Total**	**North**	**Other regions**	**Total**
	N=36	N=113	N=149	N=36	N=108	N=144
No stoves	0%	7.1%	5.4%	0%	2.8%	2.1%
1 Jumbo	11.1%	8.9%	9.4%	2.8%	12.0%	9.7%
1 ACE	2.8%	15.9%	12.8%	11.1%	15.7%	14.6%
2 Jumbos	0%	0.88%	0.7%	0%	0.93%	0.7%
2 ACE	8.3%	5.3%	6.0%	2.8%	3.7%	3.5%
1 Jumbo, 1 ACE	75.0%	62.0%	65.1%	83.3%	64.8%	69.4%

The first key observation from these results is that even with the higher prices that we introduced after the initial offers were made in the North clusters, demand for stoves appears quite high. Just 5.4% of peer group households and 2.1% of

non-peers chose not to order any stoves, while about a quarter (22% of peers and 24% of non-peers) ordered one stove, and the majority (72% of peers and 74% of non-peers) chose one of the two stove combinations. **The Jumbo-ACE combination was the dominant choice, selected by 65% of peers and 69% of non-peers.**Once households selected which stoves they wanted to purchase, the study team placed an order to import the required number of stoves from their manufacturers (ACE, located in Lesotho, and Greenway, located in India). Stoves were then distributed to households in October of 2017. ORGIIS visited each household and collected an initial deposit for each stove; households that could not pay the deposit did not receive stoves. Households that received stoves then had approximately six months (until April of 2018) to complete payments. **Table 3** shows the number of households that ordered ACE stoves, received those stoves (i.e., paid the initial deposit), and completed payments, by the randomly assigned ACE price level. Up to GHC 60, all of the households that ordered ACE stoves were able to complete their payments. At higher prices (GHC 120-240), roughly one quarter to one third of households that ordered stoves initially were not able to complete their payments and had to return their stoves at the end of the study.

Table 3. Households ordering and paying for ACE stoves by price group

ACE stove price (GHC)	# Households Ordering 1 ACE Stove	# Households Ordering 2 ACE Stoves	Total # Households Ordering ACE	# Households Receiving Stoves	# Households Completing Payments
15	12	0	12	12 (100%)	12 (100%)
30	55	2	57	57 (100%)	57 (100%)
60	44	5	49	49 (100%)	49 (100%)
120	43	3	46	45 (98%)	34 (74%)
240	82	4	86	76 (88%)	56 (65%)

One key finding from our study is that households strongly preferred the *combination* of the two different types of improved stoves (ACE and Jumbo). **Table 4** shows the mean willingness to pay (WTP) for the two different types of stoves and the stove combination, based on final acquisition and payment data. Mean WTP for the first purchased ACE stove is estimated at 145 cedi (95% confidence interval: 109-182). This compares with an estimated WTP of 42 cedi for the first purchased Jumbo stove. However, consumers placed a high value on the ACE and Jumbo stoves purchased together as a package. When both ACE and Jumbo stoves are acquired, consumers are willing to pay an additional 118 cedis. While mean WTP for a single ACE stove is 39% of the market price, the mean WTP for the stove combination is 59% of the total market price.

Table 4: Willingness to pay for stoves, based on final acquisition data

	First ACE Stove	First Jumbo Stove	Additional Premium for ACE/Jumbo Stove Combination
Mean WTP	145	42	118
[95% CI]	[109 – 182]	[7 – 81]	[75 – 175]
WTP as % of market price	39%	28%	
Total WTP, % of combination price			59%

Note: Assuming market prices for ACE (372 cedi) and Jumbo (150 cedi)

Figure 1a models average stoves ordered and **Figure 1b** models final stoves acquired along ACE price points. We model ACE demand with and without the presence of Jumbo stoves, and this has a strong impact on results.

Following the law of demand, **Figure 1b** illustrates that higher ACE prices reduce the number of ACE stoves purchased. At the ACE market price (assumed 372 cedis) and the Jumbo market price (assumed 150 cedis), our model predicts an average of 0.071 ACE stoves demanded. In other words, for every 100 potential consumers given this purchasing choice, about 7 ACE stoves would be purchased. With no presence of Jumbo stoves, our model predicts 4 ACE stoves sold per 100 potential consumers. It is immediately clear that predicted demand was much higher at the point of ordering (**Figure 1a**) compared to true demand reflected in final acquired stoves (**Figure 1b**), and this difference is particularly stark as the cost of the ACE stove approaches market prices.

Figure 1a: Estimated ACE and Jumbo Stoves Demanded by Price Levels – Ordered

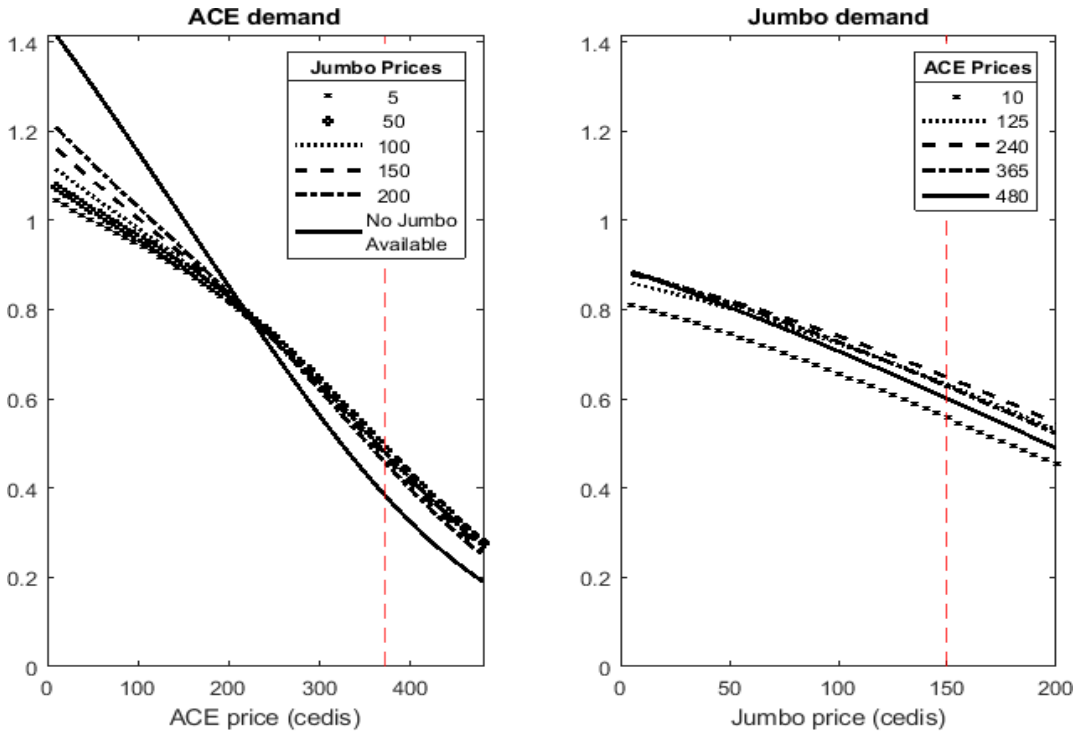
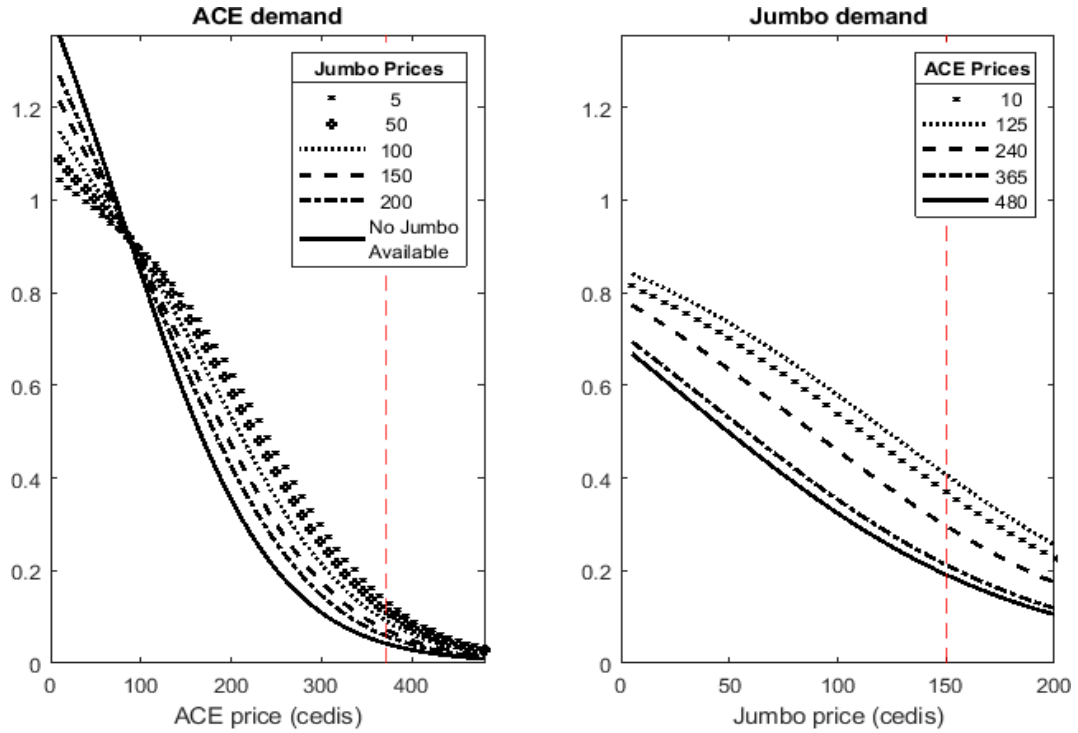


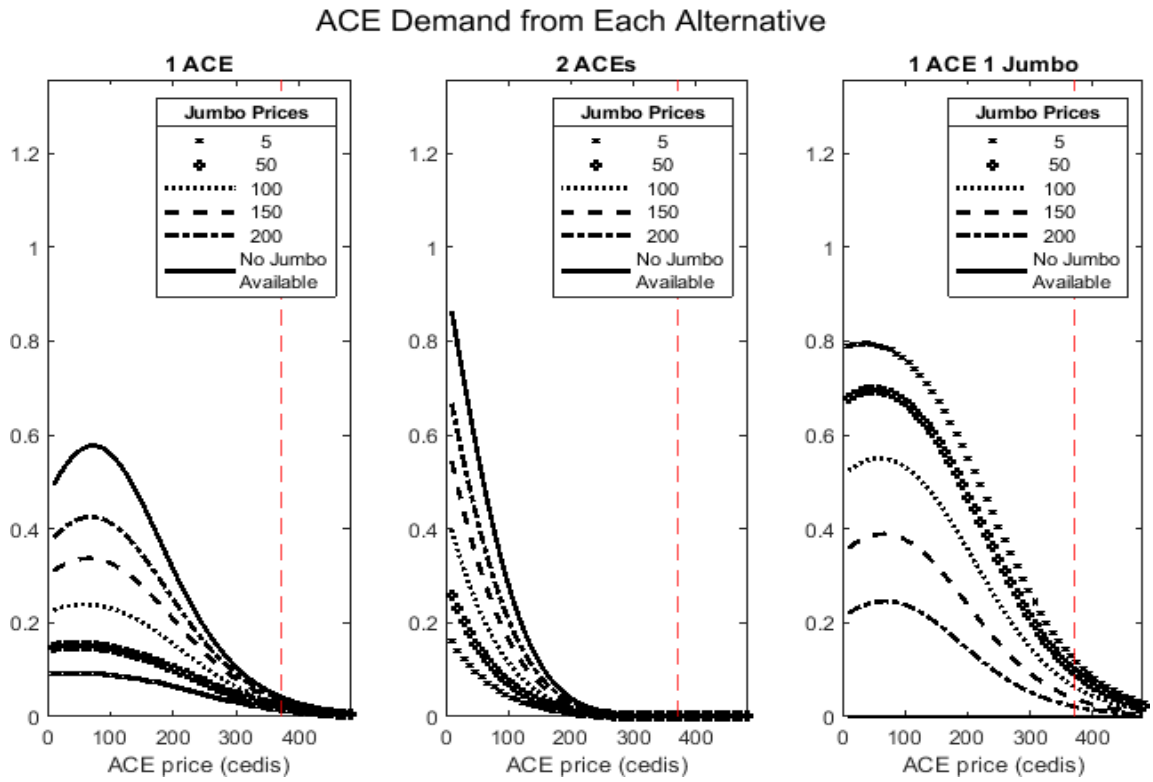
Figure 1b: Estimated ACE and Jumbo Stoves Demanded by Price Levels – Acquired



Higher Jumbo stove prices can either help or hurt the demand for ACE stoves. At ACE prices below ~86 cedis, higher Jumbo prices simply push consumers to purchase more ACE stoves. One would generally expect this dynamic. However, above an ACE price of 86 cedis, higher Jumbo prices - or the absence of a Jumbo stove option - will actually *reduce* ACE demand. This is because consumers place an extra value on having a *combination* of ACE and Jumbo stoves, and higher Jumbo prices increase the "total package price" for this ACE-Jumbo combination. This dynamic is clearer in **Figure 2** which demonstrates the proportion of the total ACE demand deriving from each package: buying 1

ACE, 2 ACE, or 1 ACE and 1 Jumbo. Note that the vertical summation of the three package options total the ACE Demand in **Figure 1**.

Figure 2: ACE demand deriving from each package alternative



The demand dynamics for Jumbo stoves are somewhat different. At market prices for ACE and Jumbo stoves, there is an average demand of 21 Jumbo stoves purchased for every 100 potential consumers. When ACE prices are in the very low range, a higher ACE price (e.g. moving from 10 to 125 cedis) pushes people to purchase more Jumbo stoves. However, in the higher ACE price range (e.g. from 125 to 240+), a higher ACE price makes it increasingly cost-prohibitive to acquire the ACE-Jumbo combination. In this case, consumers are less likely to purchase anything.

Given these dynamics, especially at less subsidized rates, the availability of Jumbo stoves is likely to increase total ACE stove demand. Co-marketing by distributors may ultimately increase both ACE sales and general adoption of improved stoves.

Stove Maintenance

Out of the 253 ACE stoves that were distributed through this project, there were a total of 25 complaints between fall 2017 and spring 2018. These are summarized in **Table 5** and listed in full in **Table 6.** In 19 cases, ORGIIS was able to fix the problem and repair the stove. One stove could not be fixed and had to be replaced (Instance #16). The most common complaint was that the stove's fan stopped working, and in these cases, the stove was taken to the ORGIIS office and fixed. Of the cases where the stove was not charging, there were two instances of user error, and three stoves were fixed by replacing parts that did not work. Charging pins were changed in the office or in the field. One of the two stoves with a USB slot problem was replaced; there are no data on the other stove with this issue. The stove with the stolen panel, the stove with the charging system problem and the stove with the lamp that did not work were fixed in the office. There are no data on the solution to the battery problem. An LED light was sent to the participant whose stove was missing one.

As of January 2019, ORGIIS had logged 68 complaints (data not shown). Their biggest challenge is replacing broken and damaged parts.

Table 1. Summary of stove complaints

Complaint	Number of Instances
No LED	1
Fan stopped working	7
Not charging	5
Stove stopped working	1
Solar panel charging pin broken	3
USB slot problem	2
Stolen panel	1
Charging system problem	1
Lamp not working	1
Battery problem	1

Table 2. ORGIIS's log of stove repairs

Instance #	Date	Complaint/Problem	Solution	Date Fixed
1	2/10/2017	No LED Light	LED unit sent to her	3/10/2017
2	14/10/2017	Fan stopped working	Taken to office and fixed	17/10/2017
3	18/10/2017	Stove not charging	They didn't connect the cable to the stove, I showed them and it worked.	19/10/2017 (follow up on 30/10/2017 to verify)
4	20/10/2017	Stove not charging after several hours on charge	Faulty solar panel, so I changed a different panel for them.	27/10/2017
5	24/10/2017	Stove not charging		
6	25/10/2017	One of her two Ace stoves not charging		
7	25/10/2017	Stove not charging	She didn't remove the rubber wrapping before charging.	
8	1/11/2017	Stove has stopped working		
9	15/11/2017	Fan stopped working	Taken to office and fixed	16/11/2017
10	16/11/2017	Fan stopped working	Taken to office and fixed	17/11/2017
11	17/11/2017	Fan stopped working	Taken to office and fixed	20/11/2017
12	19/12/2017	Solar panel charging pin broken	Changed a new panel for her	29/12/2017
13	13/02/2018	Fan stopped working	Taken to office and fixed	25/02/2018
14	21/02/2018	Solar panel charging pin broken	Taken to office and fixed	12/03/2018
15	23/02/2018	Solar panel charging pin broken	Taken to office and fixed	12/03/2018
16	23/03/2018	USB slot problem	Changed a new stove for her	10/04/2018
17	10/04/2018	Solar panel charging pin broken	Fixed same day in the field	10/04/2018
18	12/4/2018	Solar panel charging pin broken	Fixed same day in the field	12/4/2018
19	12/02/2018	Solar panel charging pin broken	Taken to office and fixed	12/04/2018
20	21/02/2018	Fan stopped working, stolen panel	Taken to office and fixed	12/04/2018
21	21/02/2018	Charging system problem	Taken to office and fixed	12/04/2018
22	20/02/2018	Fan stopped working	Taken to office and fixed	12/04/2018
23	21/02/2018	Fan and lamp not working	Taken to office and fixed	12/04/2018
24	12/04/2018	Battery problem		
25	19/04/2018	USB slot problem		

Electricity Access

Our surveys did not ask specific questions addressing the way households without electricity access benefitted from the light and USB charging capacity provided by the ACE stove in the P3 household surveys. However, we did ask households about how they lit their home (**Table 7**). ACE lights were not included as a response option, so households had to either select "other" or categorize ACE lights as electricity or solar. Adding these categories together, we see that ACE households were substantially more likely to report using electric lights than households without ACE stoves, and less likely to use torches (flashlights). Use of kerosene is low overall and does not differ substantially between the ACE and non-ACE groups at endline.

Table 7. Lighting at baseline and endline

Type of Fuel	Baseline (All)	Endline			
		All	No ACE	ACE	Chi-Square p-value
Kerosene/paraffin	6.8%	1.0%	1.4%	0.8%	0.69
Torch	95.6%	62.6%	78.0%	54.0%	0.001
Phone	4.4%	1.0%	0.0%	1.6%	0.282
Electricity	30.7%	34.9%	23.9%	41.1%	0.015
Solar Lights	2.7%	13.9%	3.0%	20.0%	0.001
ACE Light	0%	11.3%	1.4%**	16.9%	0.001
Elec + Solar + ACE	32.8%	56.4%	28.2%	72.6%	0.0001

Note: Chi-squared tests in final column test for differences in proportions between the "No ACE" and "ACE" groups at endline.
**One household had an ACE during the study and reported using it for lighting, but returned it at end of study due to defaulting on payments.

Fuel Use

P3 study participants were asked about the types of fuels they had used in the past month (**Figure 8**). At endline, the proportions of participants in the ACE and non-ACE groups using wood, millet stalks and LPG/Gas over that time did not differ significantly. However, a significantly higher proportion of the ACE group reported using charcoal relative to the non-ACE group. These results are consistent with the findings of the aforementioned REACCTING study, in which recipients of the similar Philips stove were more likely to report cooking with charcoal over the past month than participants who did not receive a Phillips stove. In REACCTING, there were also no significant differences between stove groups' use of the other fuels.

Table 8. Fuel types used in the past month

Fuel Type Used in the Past Month	Baseline (All)	Endline		
		No ACE	ACE	Chi-Square p-value
Wood	85.0%	95.8%	93.6%	0.52
Millet Stalks	65.2%	46.5%	38.7%	0.29
Charcoal	55.3%	32.4%	75.0%	0.000*
LPG/Gas	3.8%	0.0%	2.42%	0.19

Note: Chi-squared tests in final column test for differences in proportions between the "No ACE" and "ACE" groups at endline.

Participants were also asked about their perceptions of the stoves' fuel use (**Figure 9**). At baseline, the majority of P3 participants thought that the ACE stove would use a lot less fuel than a 3 stone fire. At endline, those who had ACE stoves were significantly more likely to find the ACE stove more fuel-efficient than a 3 stone fire relative to participants from households that did not receive an ACE stove.

Table 9. Perceptions of ACE Stove Fuel Efficiency

How much fuel do you think the ACE stove would use?	Baseline (All)	Endline		
		No ACE	ACE	Chi-Square p-value
A lot less than 3 stone fire	96.2%	66.2%	86.3%	0.000*
A little less than 3 stone fire	2.5%	15.5%	11.3%	
A little more than 3 stone fire	---	0.00%	0.8%	
Don't know/not sure	1.4%	18.3%	1.6%	

Conclusions

Our study shows that there is demand among households in northern Ghana for the ACE stove as a home cooking appliance. This demand translates into a measurable willingness to pay for the stove, though at an amount consistently less than the stated cost of producing these stoves. The most important conditions are the price of the ACE and the availability of the lower-end Jumbo stove (or a similar model) in combination with the ACE. The data from our economic experiment show that the two stoves, rather than being perceived by households as substitutes, are highly complementary: Households' willingness to pay for the ACE+Jumbo bundle (equating to three-fifths of total factory costs) exceeds the sum of households' willingness to pay for each stove by itself.

We can also gain insight on how to enhance the efficiency of stove distribution interventions on a fixed budget, similar to what ORGIIS has done as part of this study. According to basic economics and in agreement with what we find here, the more the cost of the stove can be subsidized the more households will decide to purchase. However, larger subsidies on a fixed budget come at the expense of being able to reach fewer households with sensitization, education about the stoves, and an offer to purchase. In principle, given a budgeted amount for a subsidized distribution campaign and the objective of maximizing ACE purchases, cost-effective subsidy levels could be computed from these data for both the ACE and Jumbo stoves. These subsidy levels could be optimized to balance the reach of the campaign with stove affordability.

Some basic qualifications are also necessary in order to interpret our willingness to pay estimates. Most importantly, consumer demand is subject to the effects of marketing and the experiences of peers who have already purchased – and used – the goods in question. Our study distributed stoves in some areas that had already been enrolled in a free distribution campaign for somewhat similar high- and low-end improved cookstoves. We know that prior adopters of improved cookstoves informed households located in the same clusters about their experiences. An ongoing part of our work is to investigate the extent to which this prior peer exposure affected demand for the stoves. Likewise, future marketing campaigns by ACE (or by producers of competing technologies and products) could substantially affect household demand for these products.

A related qualification concerns stove breakage. If stove performance consistently fell short of expectations and there was a lack of support or repair services by the distributor, this could sour household demand for the stoves. As noted in this report, fan breakage and recharging issues were the most commonly reported problems with the ACE. The LED light feature also appears to be highly valued by households and ensuring continued functionality of this feature could be expected to be important in sustaining demand.

The other necessary qualification is that our estimated willingness to pay amounts have inherent statistical uncertainty, due to the limited number of households that participated in the study and some degree of persistent randomness to household economic decisions. This can be seen most clearly in **Table 4**, where the 95% confidence interval for household willingness to pay for the ACE+Jumbo bundle ranges from 38% to 88% of the estimated total factory cost of the bundle. This uncertainty would need to be taken into account by distributors in setting purchase prices and subsidy levels. The distributor would need to consider their own level of risk aversion if demand exceeded or fell short of expectations, potentially outstripping or underutilizing the available budget. One recommendation for dealing with this uncertainty in a subsidized distribution campaign would be to roll out the offers to purchase in phases, so that the distributor would not end up being obligated to fulfill subsidized orders for stoves beyond what their budget could handle. The tradeoff here could be that the distributor would then order multiple smaller shipments of stoves from the manufacturers, which could increase shipping costs and would also limit the 'bulk discounts' that might be offered by the manufacturer.

Overall, our experience suggests that there is strong potential for ACE1 uptake in Northern Ghana. Improved capacity for stove marketing, distribution, and maintenance could enhance this potential and address the need for cleaner and more efficient household energy solutions in this region.

References

1. Dickinson, K.L., E. Kanyomse, R. Piedrahita, E. Coffey, I. Rivera, J. Adoctor, R. Aligiria, D. Muvandimwe, M. Dove, V. Dukić, M. Hayden, D. Diaz-Sanchez, V. Adoctor, D. Anaseba, Y.C.-H. Slichter, N. Masson, A. Monaghan, A. Titiati, D. Steinhoff, Y.-Y. Hsu, R. Kaspar, B. Brooks, A. Hodgson, M. Hannigan, A.R. Oduro, and C. Wiedinmyer, *Research on Emissions, Air quality, Climate, and Cooking Technologies in Northern Ghana (REACCTING): Study Rationale and Protocol.* BMC Public Health, 2015. **15**: p. 126. DOI: 10.1186/s12889-015-1414-1. Available from: http://www.biomedcentral.com/1471-2458/15/126.
2. Dickinson, K.L., M. Dalaba, Z. Brown, R. Alirigia, E. Coffey, E. Mesenbring, M. Achazanaga, D. Agao, A. Moro, E. Kanyomse, J. Awaregya, C. Amoah, J.B. Aburiya, B. Gubilla, M. Hannigan, and A.R. Oduro, *Prices, Peers, and Perceptions (P3): Study Protocol for Improved Biomass Cookstove Project in Northern Ghana.* BMC Public Health, 2018. **18**: p. 1209. DOI: https://doi.org/10.1186/s12889-018-6116-z.