Project Gaia Nigeria Pilot Study Final Report

Results of Project Gaia's CleanCook Methanol Stove Pilot Study in Delta State, Nigeria

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Sponsors

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(Ministry of Power & Energy)

USEPA – PCIA

Stokes Consulting Group

1.0 Background

In February 2007, Project Gaia Research Studies, a research project facilitated in Nigeria by the Centre for Household Energy and Environment, Stokes Consulting Group and Dometic, with grants from the United States Environmental Protection Agency (USEPA) under its Partnership for Clean Indoor Air and Delta State, and support from the Delta State's Ministry of Power and Energy launched the pilot testing of 150 methanol fueled CleanCook stoves in 150 randomly selected homes from the three senatorial districts of Delta State, Nigeria.

1.1 Initial Mini-pilot Study

Beginning in 1998, Dometic AB (formally of Electrolux) has been actively engaged in research to determine the feasibility of adapting the *Origo-series alcohol stoves* (and other Dometic alcohol appliances) for use in developing countries using denatured methanol as a stove and household energy fuel to supplement the limited supply of ethanol currently available in developing countries. Methanol is potentially a cheap and abundant liquid fuel particularly in Nigeria because of the availability of natural gas of which a significant volume is currently being wasted through years of gas flaring.

Methanol is easily and cheaply processed from natural gas. Dr. Charles Andy Stokes of the Stokes Consulting Group, an energy and renowned methanol expert, originally developed this concept for the developing nations and brought it to Electrolux. This effort culminated in a 15-stove pilot study in Delta State, Nigeria, in collaboration with the state's Ministry of Power and Energy. Assisted by Winrock International, this effort was facilitated by the Centre for household Energy and Environment and the Delta State Ministry of Power and Energy.

Dometic AB provided 15 new prototype CleanCook stoves specially designed for this project. Project results were published in January 2004 with positive results, including the finding that: ***"All respondents, representing 100% of the study group, say they would buy the stove to replace their current cooking devise, if there would be regular supply of methanol fuel to run the stove."*** This success of this test run led to the extensive 150-stove pilot study.

1.2 Aims and Objectives of the Pilot Study

The pilot study, in the course of the three months duration, empirically examined the following cooking energy issues;

(a) Consumers' response to the methanol stove and its fuel over a range of issues and indicators including; acceptability of the CleanCook stove and methanol fuel; affordability of both stove and fuel; efficiency of stove and its fuel as well as safety of the stove and its fuel;

(b) Consumers' attitudes about switching to alcohol stove and its fuel, and the limitations placed upon their choices;

(c) Necessary modifications to be made to the stove;

(d) Safety analysis of methanol fuel handling and distribution logistics;

(e) The pricing estimates for both stove and fuel.

1.3 Methodology of Survey, Household Selection and Household Monitoring Procedure

Over a period of 3 months between March and May 2007, 150 households represented by low, middle and high income groups across three major towns and their 17 sub-communities participated in the study. Bi-weekly questionnaire and daily fill-out sheet were the main survey instruments used in the methodology. The data analyzed in the this report accounted for a total of 9,230 daily fill-out sheets from the daily monitoring of cooking tasks in the homes relating to cooking time, amount of fuel used, user satisfaction with the stove and fuel, and the price estimates consumers are willing to pay for both stove and fuel. Data were analyzed using simple percentages.

Using predetermined selection criteria, Project Gaia surveyors carefully distributed the 150 stoves among the participating households in their respective survey locations assigned to them. This was followed by the distribution of denatured methanol every week to the surveyors in 2-fifty litre jerry cans containing 100 litres from which they dispensed into their 10-litre working jerry cans, which they carried along as they distributed fuel to the participating households. For ease of fuel distribution, the surveyors were each given a graduated plastic jug into which methanol was measured in 2.4 litres from the 10 litre jerry cans into the 2 canisters in 1.2 litre measurement apiece.

Project Gaia surveyors were instructed *NOT* to deliver methanol to the families without first dispensing fuel directly into the stove canisters. Surveyors were instructed to watch out for some respondents who might be curious to the extent they would request for their fuel supplies in containers so as to fill the canisters themselves under the guise of assisting the surveyors reduce their visits.

Furthermore, the surveyors were always ready and on hand to respond to any needs, questions, concerns and situations that came up in any of the pilot study homes.

On the issue of safety, the surveyors each spent a considerable period, sometimes up to an hour, in each home prior to placement of stoves to go through the following tasks:

(a) A brief background of the project;
(b) The nature of methanol and its application as a household fuel;
(c) The different parts of the CleanCook stove and their functionality;
(d) The identified primary cook was trained to operate the stove – *(tasks carried out during the training were lighting the stove, turning off the stove and cleaning the stove);*
(e) Water boiling test performance on the stove

Follow-on assignments involved the surveyors visiting each household everyday for the first 2 weeks of the study to ensure that everything was going on as planned, and to familiarize the families with the stoves and fuel in order to make them comfortable with the new cooking technology.

2.0 Description of the Pilot Study Location – Delta State

Delta State, which was formed out of the defunct Bendel State in 1991, is divided into 25 local government areas, which operate under 3 senatorial districts. Delta State lies roughly between longitude 5° 00' and 6° 45' East and latitude 5° 00' and 6° 30' North. The state has a total land area of approximately 18,000km of which 6,000km is mangrove swamp situated along a coastline stretching over 160 km. The major rivers in Delta State are the Niger, Ase, Forcados, Warri, Ethiope, Benin, Escravos and Ossiomo. The total population of the state according to the 2006 population census is 4,098,391. The majority of the population lives in urban areas. The major ethnic groups in Delta State are Urhobo, Ibo, Ijaw, Isoko and Itsekiri.

Endowed with 40 per cent of Nigeria's total oil and gas resources, or some 10 to 16 billion barrels of oil and some 160 X 10^{12} cubic feet of natural gas, Delta State is awash in oil and gas wealth and possibly the richest oil and gas jurisdiction in sub-Saharan Africa. Despite this enormous wealth in energy resources, the vast majority of the population is not only extremely poor economically, but energy poor as well. An estimated 98 per cent of households lack access to quality cooking and lighting fuels (Obueh, 2006). This situation compels families to depend wholly on inferior and health damaging fuelwood and kerosene fuel. The people of Delta State are desperate for clean cooking energy.

As one travels throughout Delta State, fuelwood gathering from forests that have become marginal, together with long queues of people waiting to purchase kerosene that is perennially scarce, is in evidence everywhere. For the most part, women are seen in the evenings returning home carrying enormous bundles of fuelwood on their head after a full day's drudgery of wood gathering. CEHEEN estimates that a typical rural woman in Delta State spends six hours gathering fuelwood (Obueh, 2006).

In the urban centres, up to 9 per cent of the households depend on kerosene to supplement fuelwood in some cases. About 1 per cent depends on LPG. The use of kerosene has been hampered by a corrupt distribution system, poor quality and condensate –laden kerosene that burn with high emissions of soot and particulate matter. Contaminated kerosene has continued to claim lives in Delta State.

These problems are compounded by pollution from years of uncontrolled gas flaring from an estimated 50 gas flare sites scattered around Delta State. An estimated 80 per cent of the 2 billion standard cubic feet of natural gas that Nigeria flares daily is from the gas fields in Delta State. It is ironic that the people of Delta State must cut down their valuable forests to cook literally in the sight of oil rigs and flow stations.

Despite its oil and gas wealth, 95% of people in Delta State use either some fuel wood or only fuel wood for cooking. Some communities around the oil fields must cut down their valuable trees to cook in sight of oil rigs and flow stations

Delta's topography and climate make it ideal for many types of agriculture. Cassava, yam, and maize are the main food crops produced, while oil palm and rubber are the predominant cash crops. Although growth in the Delta economy has been dominated by non-agricultural sectors, as much as 70 per cent of the population is engaged in subsistence farming, while another 10 per cent is engaged in large-scale commercial farming and fishing activities.

2.1 Profile of the Pilot Study Sites and sub – Locations

The pilot study was conducted in three main towns in Delta State: Asaba, Warri and Abraka. The study covered 17 communities and villages in these three major towns.

2.1.1 Asaba Pilot Study Location and sub-Locations

Asaba is the capital of Delta State and also the administrative headquarters of Oshimili South Local Government Area. Asaba is situated along the River Niger, which forms its South – East boundary. It is Nigeria's gateway to the commercial Eastern Nigeria. Education level is high, being an administrative centre. It is dominated by civil servants, who constitute the bulk of the high and middle income categories of the population. The Ministry of Power and Energy, our local partner, is located in Asaba.

Asaba has a rich cultural heritage that dates back to Nigeria's pre independence era, when it once served as the capital of the Royal Niger Company during the British rule.

Sixty families participated in the study in Asaba pilot location. The importance of Asaba being the state capital and home to over 80 per cent of the civil servants in the state informed the allocation of 60 stoves, representing 40 per cent of the pilot study stoves. The other communities and villages that constituted Asaba pilot location were Okwe, a fishing village adjoining Asaba on the bank of the River Niger that received 10 stoves; Ogwashi-Uku, an agrarian town and headquarters of Aniocha South Local Government Area that was allotted 5 stoves; Obior, a rice faming community 40 km from Asaba was allocated 3 stoves. Agbor, a commercial and agrarian town and also

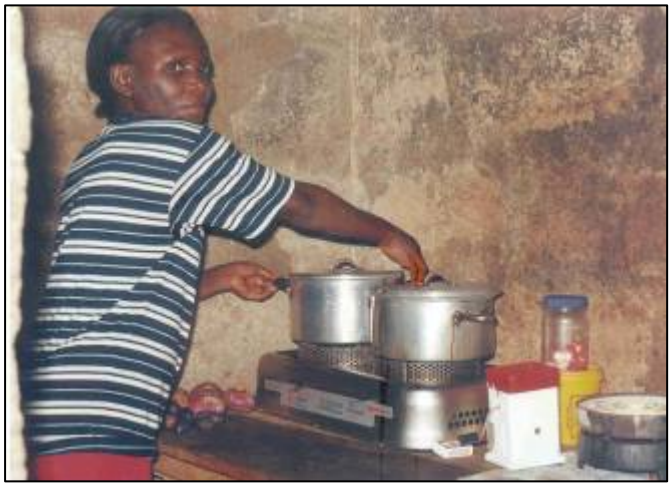
the headquarters of Ika South Local Government Area was allotted 7 stoves, while its neighbouring village, Umunede, got 5 stoves. 15 stoves were placed in Government residential quarters in the homes of civil servants. Ibusa, a town 5 km from Asaba was allocated 5 stoves, while Asaba metropolis was allotted 10 stoves.

"The CleanCook stove is very safe. It is much safer and cleaner than my kerosene stove, which I have not touched ever since you brought this CleanCook stove to me. As you can see, my pots are now cleaner than before. I am very satisfied with the new stove" - Mrs. Florence Egede, Asaba, Delta State

2.1.2 Abraka Pilot Study Location and sub-Locations

Abraka is a quiet agrarian town located in Ethiope East Local Government Area that has a population of 113,929 people (National Population Commission, Asaba, 2006). It is predominantly a low income community. The location of the state's university in the town has, however, ensured the presence of some 5% and 2% middle and upper income groups respectively. The university population has increased the entire population of Abraka to some 25,000 inhabitants. Abraka is home to the famous Ethiope fresh water river, which gives the community its unique ecology. The presence of a university informed the high level of education in the sample size of this community, where 42% of the heads of the households interviews had basic education some up to university level.

Forty five households participated in the study. Twenty of the 45 stoves were placed in Abraka main town, while 7 stoves went to Obiaruku a neighbouring community, which serves as satellite town to the university population. Sapele, the administrative headquarters of Sapele Local Government Area, was allocated 10 stoves. Its neighbouring town, Oghara, was allotted 8 stoves.



"It is really a CleanCook stove. It is faster than my kerosene stove. I use less fuel in cooking the same food that I cooked with my kerosene stove; but you should make the canisters bigger so that it can cook for longer hours" - Mrs. O Ossai, Warri, Delta State, Nigeria

2.1.3 Warri Pilot Study Location and sub-Location

Warri, a port town, located in the south central part of Delta State comprises 3 local government areas: Warri North, Warri South and Warri South-West. It has an area cover of 33.2sq km and lies along the northern bank of Warri River with typical mangrove vegetation. The coastal city with a total population of 326,643 inhabitants is the economic hub of Delta State as almost all the oil and gas companies operating in Delta State are located in Warri, as are over 80% of industries and manufacturing firms in the state. Warri is the divisional headquarters for Shell Petroleum Development Company (SPDC) and also a swamp location for exploration and production of oil for SPDC. Other oil companies like Chevron and Wilbros have offices in Warri. One of Nigeria's four petroleum refinery and petrochemical plant is located in Warri, along with Nigeria's foremost steel company, Delta Steel Company. Several oil servicing and petrochemical companies are also located in Warri, which also has a functional deep water port.

A total of 45 households participated in the pilot study. Warri town and neighbouring Effurun and Orhuwhorun towns were allocated 20 stoves. Delta Steel Town, the residential quarters for the staff of the steel complex, was allotted 12 stoves, while Agbarho and Ughelli, headquarters of Ughelli North Local Government Area, were allocated 13 stoves.

3.0 Data Presentation and Analysis

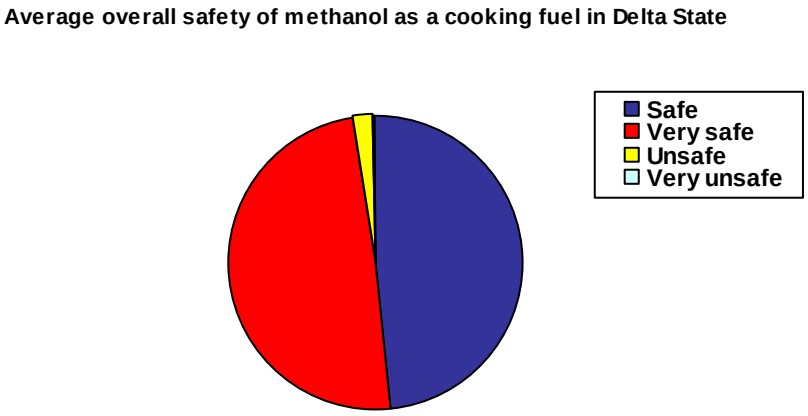
Bi-weekly data are presented in 6 sections: (a) acceptability of methanol as a cooking fuel; (b) acceptability of stove; (c) willingness to pay for fuel and stove; (d) methanol fuel distribution and packaging technique; (e) stove improvement suggestions; (f) health impact of methanol fuel and stove cooking system.

3.1 Acceptability of Methanol as a Cooking Fuel

Acceptability of methanol is broken down into 3 sub groups of data represented by the following tables and charts:

Table 1: Overall safety of Methanol as a cooking fuel

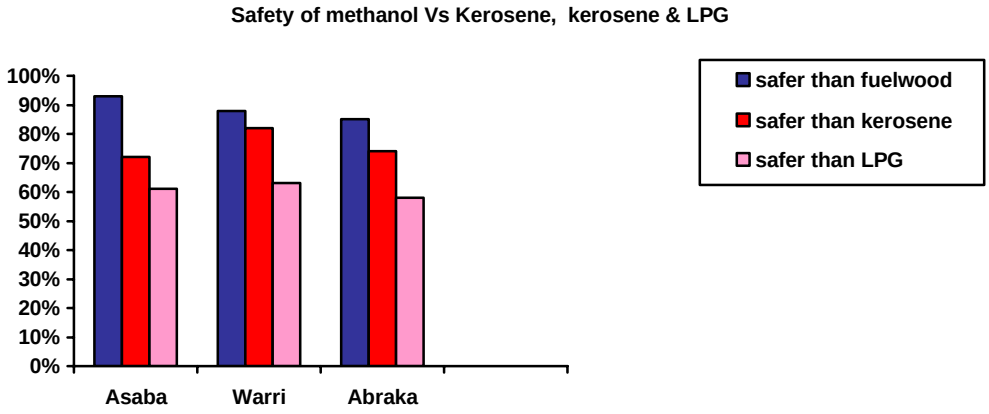
	Asaba (%)	Warri (%)	Abraka (%)	Average %
Safe	46	56	43	48.3
Very safe	52	41	54	49.0
Unsafe	2	2	3	2.3
Very unsafe	-	1	1	0.3
Total	100	100	100	100



From table 1 above, when asked, "How you would rate the overall safety of methanol as a cooking fuel? The following were the responses of those that said "Safe", 46% of the survey families in Asaba, 56% in Warri, while 43% in Abraka. On the average, 48.3% rated methanol as a safe cooking fuel. The responses of those that said methanol as a cooking fuel was "Very Safe" were: 52% in Asaba, 41% in Warri and 54% in Abraka. Overall, 49% said methanol was very safe. The responses of those that said the use of methanol as a cooking fuel was "Unsafe" were: 2% in Asaba, 2% in Warri and 3% in Abraka. Overall response that regarded methanol as unsafe cooking fuel was 2.3%. Only 1% representing an average response of 0.3% regarded methanol as "Very Unsafe" to be used as a cooking fuel. Overall, 97% of the households that participated in the study considered methanol as a very safe cooking fuel.

Table 2: Safety of Methanol Vs Kerosene, LPG and Fuelwood

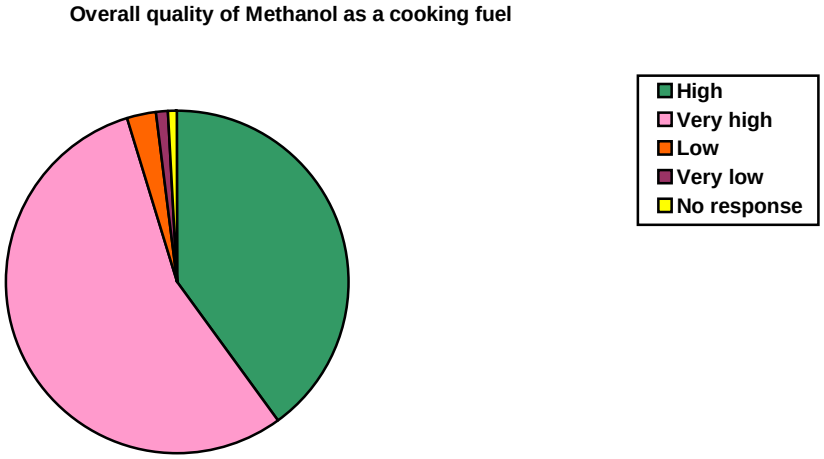
	Asaba	Warri	Abraka
Safer than fuelwood	93%	88%	85%
Safer than kerosene	72%	82%	74%
Safer than LPG	61%	63%	58%



From table 2 above, households were asked to compare the safety of methanol versus kerosene, LPG and fuelwood. In Asaba, 93% said that they found methanol fuel "Safer than Fuelwood", 72% answered that methanol fuel was "Safer than Kerosene", while 61% of households that owned LPG said methanol fuel was "Safer than LPG". In Warri, 88% said methanol fuel was "Safer than Fuelwood", 82% said methanol fuel was "Safer than Kerosene", while 63% said methanol was "Safer than LPG". In Abraka, 85% considered methanol fuel "Safer than Fuelwood", 74% considered it "Safer than Kerosene", while 58% said it was "Safer than LPG" Generally, the households were of the view than methanol was a safer fuel to use for cooking than the fuels they are familiar with.

Table 3: Overall quality of Methanol as a cooking fuel

	Asaba	Warri	Abraka	Average %
High	42	38	40	40.0
Very high	53	57	56	55.3
Low	03	03	02	2.7
Very low	01	02	01	1.3
No response	01	-	01	0.7



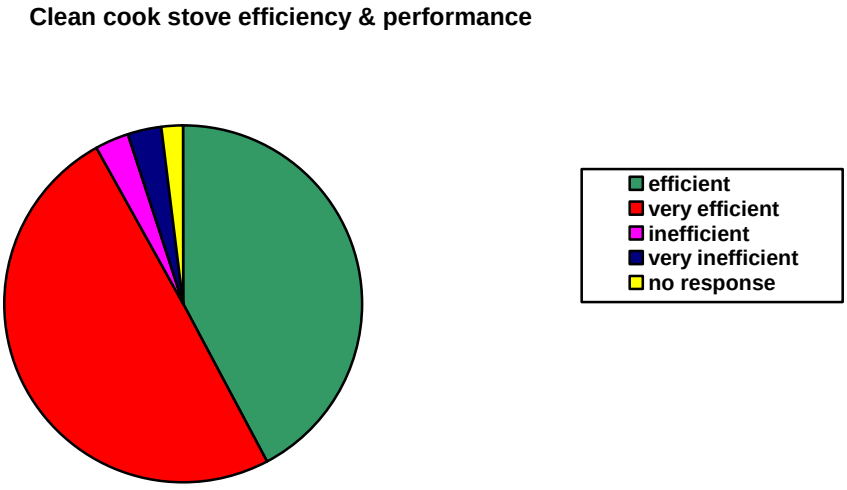
From table 3 above: When asked to rate the overall quality of methanol as a cooking fuel, 42% of the study participants in Asaba rated the quality of methanol as a cooking fuel to be "High". Respondents in Warri that rated methanol quality to be "High" were 38%, while 40% of the participants in Abraka said methanol as a cooking fuel was of "High" quality. Asaba had 53% who rated methanol quality as "Very High". 57% in Warri gave methanol a "Very High" quality rating, while 56% in Abraka gave methanol a "Very High" quality rating as a cooking fuel. 03% of the survey respondents in Asaba gave methanol as a cooking fuel a "Low Rating", same as respondents in Warri. 02% in Abraka rated methanol as a "Low" quality cooking fuel. Respondents in Asaba that rated methanol as a "Very Low" quality cooking fuel were 01%, same as respondents in Abraka. 02% in Warri rated methanol as a "Very Low" quality cooking fuel. 01% of Asaba participants gave no response, same as those in Abraka. The general response from the survey respondents in Delta State shows that 95.3% rated methanol as a high quality cooking fuel.

3.2 Acceptability and Users' Satisfaction of the CleanCook Stove

Acceptability of methanol is broken down into 4 sub groups of data represented by the following tables and charts:

Table 4: CleanCook Stove Efficiency and Performance

	Asaba	Warri	Abraka	Average %
Efficient	40	50	38	42.7
Very efficient	52	42	57	50.3
Inefficient	4	3	2	3.0
Very inefficient	2	3	1	2.0
No response	2	2	2	2.0

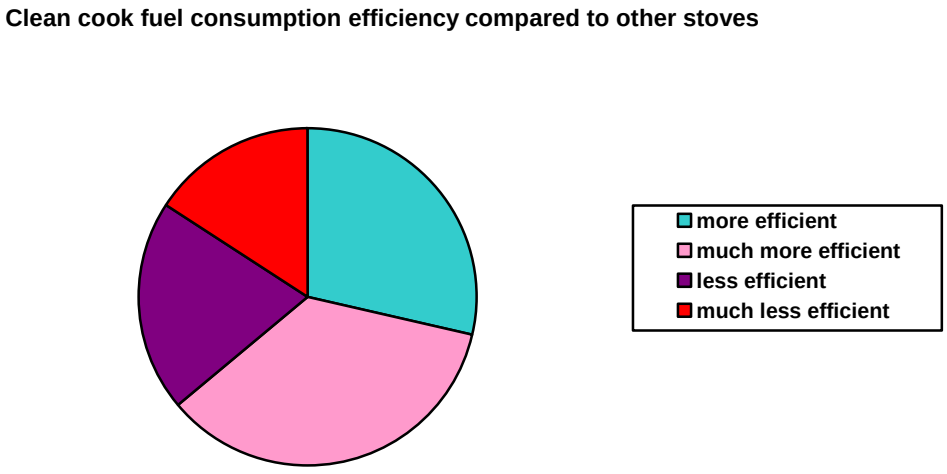


From table 4 above, study participants were asked to rate the performance and efficiency of the CleanCook stove. 40% respondents rated the stove to be "Efficient"

in Asaba pilot study location. Warri had 50% of its respondents that rated the stove as being "Efficient", while 38% in Abraka considered the CleanCook as being "Efficient". 52% in Asaba said the stove was "Very Efficient". 42% in Warri gave the stove a "Very Efficient" rating, while 57% in Abraka regarded the stove to be "Very Efficient". 4% of the participants in Asaba said the performance of stove was "Inefficient". 3% gave the stove "Inefficient" rating in Warri, while 2% said the performance of the stove was "Inefficient" in Abraka. 2% of the respondents in Asaba gave the CleanCook stove a "Very Inefficient" rating. 3% in Warri said the performance of the stove was "Very Inefficient", while 1% in Abraka gave a "Very Inefficient" rating. 2% of the respondents in each of the 3 locations did not respond to the question. On the whole, 93% of the respondents in the study rated the CleanCook stove to be of high efficiency and performance.

Table 5: CleanCook Stove Fuel Economy Compared to other stoves

	Asaba	Warri	Abraka	Average %
More efficient	32	26	28	28.7
Much more efficient	28	40	38	35.3
Less efficient	22	21	18	20.3
Much less efficient	18	13	16	15.7



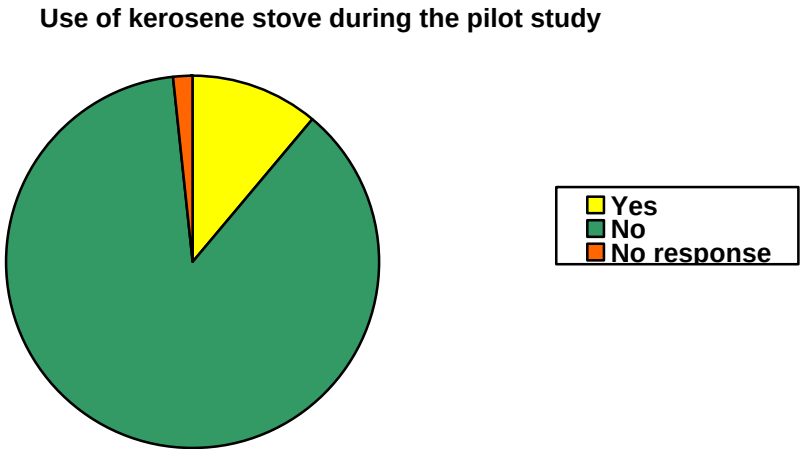
From table 5 above, respondents were asked to compare the fuel economy of the CleanCook stove to the other stoves they were familiar with. While 32% of the study participants in Asaba considered the CleanCook stove to be "More Efficient" than the other stoves they were familiar with, 26% gave the same response in Warri. 28% in Abraka said the CleanCook stove fuel economy was "More Efficient" than the other stove they had used before the study. In Asaba, 28% said the fuel economy of the stove was "Much more efficient" than the other stoves they were familiar with. 40% of the respondents in Warri rated the fuel economy of the CleanCook stove as being "Much more efficient" than the other stoves they had used in the past. 38% of the

study participants in Abraka gave the fuel economy of the CleanCook stove a "Much more efficient" rating.

However, 22% of the study participants in Asaba gave the CleanCook stove fuel economy a "Less Efficient" rating. In Warri, 21% regarded the fuel economy of the CleanCook stove as being "Less Efficient", while 18% in Abraka did rate the fuel economy of the CleanCook stove as "Less Efficient" than the other stoves they were familiar with. In Asaba, 18% said the CleanCook stove was "Much less efficient" in fuel economy than other stoves. 13% in Warri gave the CleanCook stove a "Much less efficient" fuel economy than the other stoves they had used, while 16% of the respondents in Abraka said the fuel economy of the CleanCook stove was "Much less efficient" than that of the other stoves they had used. Overall, 64% of the study participants regarded the fuel economy of the CleanCook stove over the other stoves they were familiar with while 36% gave the fuel economy of the CleanCook a less efficient rating than the other stoves.

Table 6: Use of kerosene stove during the pilot study

	Asaba	Warri	Abraka	Average %
Yes	17	6	10	11
No	81	93	88	87.3
No response	2	1	2	1.7



From table 6 above, as a way to further find out users' satisfaction with the new cooking technology, participants were asked if they used kerosene stove while the CleanCook stove was in their homes. Those that said they used kerosene gave reasons that are explained in the discussion section of this repot. In Asaba pilot study location, 17% said they used kerosene during the pilot study. 6% of the respondents in Warri admitted using kerosene to cook while the pilot study was going on. Abraka had 10% of respondents who admitted using kerosene stove and its fuel while the CleanCook stoves were still in their homes. In Asaba, 81% did not use kerosene during the pilot study. Warri had 93% of respondents who did not use kerosene while the pilot study was on, while the respondents that did not use kerosene in Abraka during the pilot study were 88%. Those that did not give any response in Asaba were 2%. In Warri, 1% had nothing to say, while 2% in Abraka also declined comments. Overall, while

some 98.3% stuck to the CleanCook stove during the entire course of the study in Delta State, only 1.7% at some point used kerosene to cook during the pilot study.

Table 7: General user's satisfaction with the methanol fueled stove

	Asaba	Warri	Abraka	Average %
Yes	96	93	98	95.7
No	2	6	2	3.3
No response	2	1	-	1

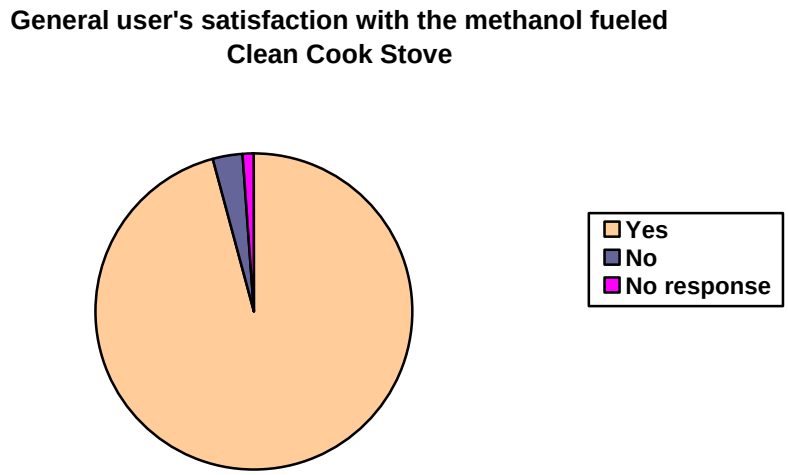
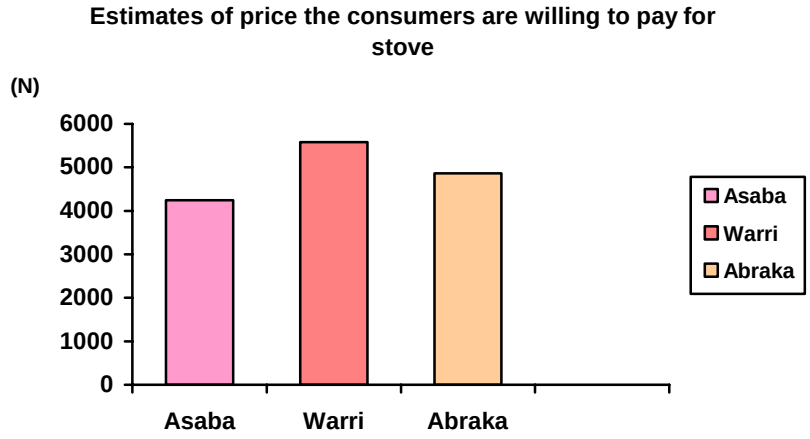


Table 7 shows users' response to the question asked if they were satisfied with the methanol-fueled CleanCook stove after using it for 10 weeks. In Asaba, 96% answered "Yes" that they were satisfied with the methanol-fueled CleanCook stove. 93% in Warri said "Yes", while 98% in Abraka gave a "Yes" answer to the question. The respondents that gave a "No" answer in Asaba were 2%, same as the respondents that said "No" in Abraka. 6% returned a "No" answer in Warri. While 2% did not respond to the question in Asaba, only 1% failed to respond in Warri. All respondents in Abraka gave answers to the question. Remarkably, about 96% of the survey groups said they were satisfied with the methanol-fueled CleanCook stove.

3.3 Willingness to Pay for Stove and Fuel

Table 8: Price estimates consumers are willing to pay for stove and fuel

	Asaba	Warri	Abraka	Total Average
Stove				
Average amt of both high & low price(Naira)	4,250	5,582	4,865	4,899
Fuel				
Average amt of both high & low price per litre (Naira)	42.5	37.5	47.5	42.5



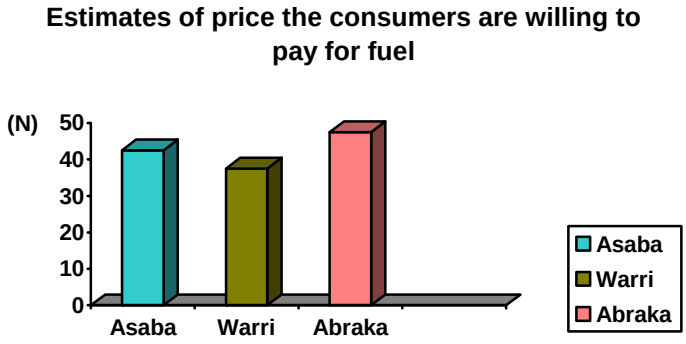


Table 8 shows consumers' willingness to pay pricing estimates for both stove and fuel across the 3 main pilot locations. The estimates for the average high and low prices the respondents were willing to pay for both stove and fuel are shown for each location. In Abraka, the average for both low and high prices respondents said they would pay for the stove was ₦4,250. The average for both low and high prices respondents said they were willingness to pay for the stove in Warri was ₦5,582, while that of Abraka was ₦4,865. For the fuel, the average for both low and high prices respondents said they would like to pay for a litre of methanol in Asaba is ₦42.5k. Those in Warri said they would pay ₦37.5k for a litre of methanol, while Abraka respondents gave an average low and high price estimate of ₦47.5k for a litre of methanol. From the total average, consumers in the pilot study are willing to pay approximately ₦5,000 for the two-burner CleanCook stove. The same consumers said they are willing to pay the sum of ₦43 for a litre of methanol.

3.4 Methanol Distribution Method

Methanol distribution method is broken down into 2 sub groups of data represented by the following tables and charts:

Table 9: Consumers satisfaction with methanol distribution method

	Asaba	Warri	Abraka	Average %
Yes	52	47	58	52.3
No	43	51	37	43.7
No response	5	2	5	4

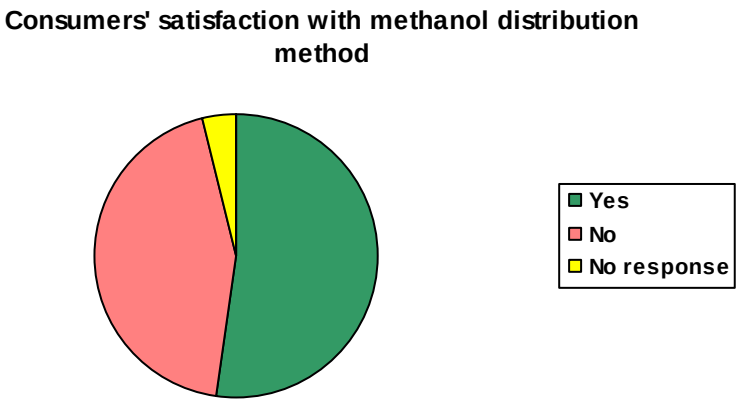


Table 9 shows responses given by study respondents when asked if they felt satisfied with the way methanol fuel was distributed to them in the stove canisters. In Asaba 52% gave a "Yes" answer saying they were satisfied with the way methanol was distributed to them in the stove canisters. 47% of the respondents answered "Yes" in Warri, while in Abraka 58% did give a "Yes" answer. Conversely, 43% of respondents in Asaba gave a "No" answer saying they were not satisfied with the way methanol was delivered to them in the stove canisters. 51% of Warri respondents said "No", while 37% in Abraka also gave a "No" answer to the question. While 5% in Asaba did not respond to the question, same as the number in Abraka that did not respond; 2% in Warri failed to respond to the question. Overall, 52.3% of the study participants favoured the use of the stove canisters to distribute methanol while 43.7 did not favour methanol distribution in the stove canisters.

Table 10: Preferred methanol distribution method

Options	Asaba	Warri	Abraka	Average
Refillable plastic bottles	33	34	40	35.7
Stove canisters	28	44	48	40
Graduated jerry cans	26	17	9	17.3
Sachets	13	5	3	7

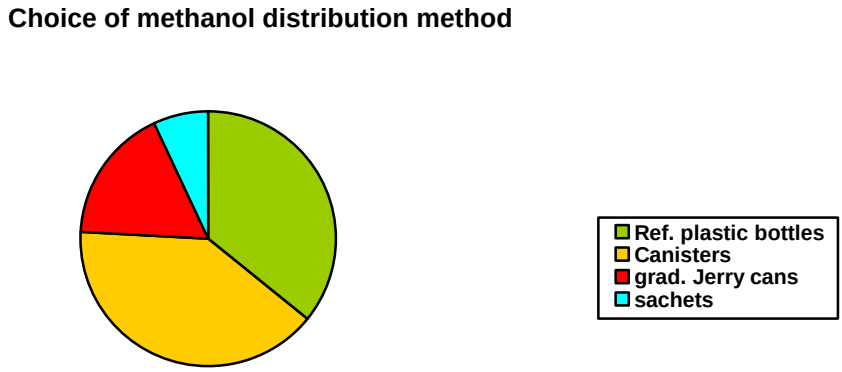
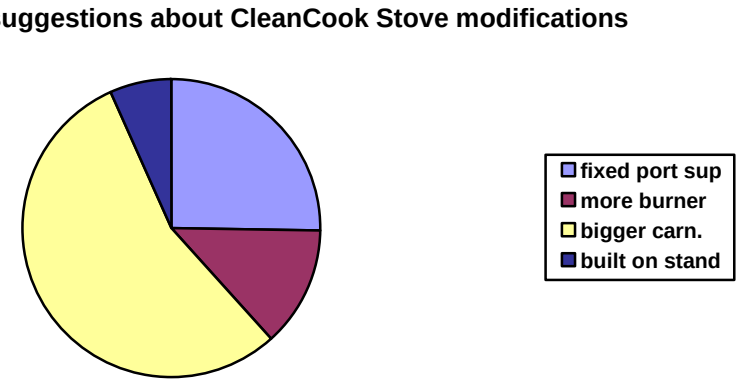


Table 10 shows participants' responses when they were asked to choose their most preferred method methanol should be sold to them against the background of the explanation surveyors gave to them prior to the placement of stoves in their homes concerning the peculiar nature of methanol. Options given to them ranged from; refillable plastic bottles, stove canisters, graduated jerry cans to sachets. In Asaba, 33% said they would prefer methanol be sold to them in "Refillable plastic bottles". 34% in Warri preferred "Refillable plastic bottles", while 40% in Abraka said they would prefer to buy methanol in "Refillable plastic bottles". In Asaba, 28% of the respondents said they would prefer to buy methanol in the "Stove canisters", Warri had 44% who preferred methanol purchase in the "Stove canisters", while 48% in Abraka preferred to buy methanol in the "Stove canisters". Buying methanol in "Graduated jerry cans" was preferred by 26% of the household in Abraka study location. 17% in Warri wished methanol was distributed to them in "Graduated jerry cans", while 9% in Abraka wanted "Graduated jerry cans". The other option considered was the sale of methanol in sachets. In Asaba, 13% opted for methanol in "Sachets". 5% preferred "Sachet" in Warri, while 3% opted for it in Abraka. In the entire pilot study location, the most preferred choice of methanol distribution is between refillable plastic bottles and stove canisters. However, more consumers, 40% of the study population, preferred methanol distribution in the stove canisters while 35.7% preferred methanol distribution in refillable plastic bottles.

3.5 CleanCook Stove Modification Suggestions

Table 11: Consumers' suggestions about CleanCook Stove modification

Response	Asaba	Warri	Abraka	Average%
Fixed pot support	25	21	30	25.3
More burners	12	16	11	13
Bigger canisters	61	56	48	55
Built onto a stand	2	7	11	6.7

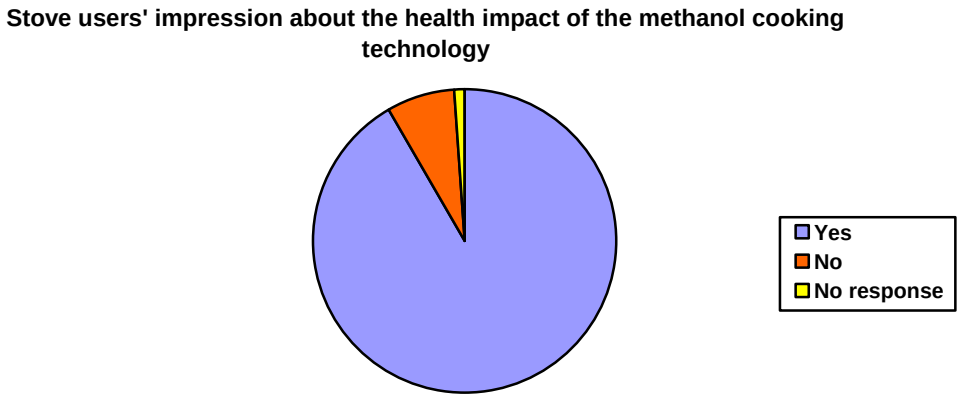


When asked what modifications they would like to see on the stove, 25% of study respondents in Asaba said they would like to have a "Fixed pot support". In Warri, 21% of the study participants said they would prefer the stove to have "Fixed pot support. This was corroborated by 30% of the respondents in Abraka. 12% in Asaba said the stove should be modified to have more burners. 16% in Warri said the same thing, while 11% in Abraka corroborated. In Asaba, 61% of the stove users preferred the stove having "Bigger canisters" than the present ones. 56% in Warri said they would like to see "Bigger canisters" as the modification to be made on the stove. 48% in Asaba agreed with this preference. In Asaba, 2% of the study participants would rather have the stove "Built onto a stand". This preference was agreed by 7% in Warri, while 11% in Abraka gave the same response. In all, majority of the respondents, 55% of the study population, would prefer the stove to have large capacity canisters as their most pressing modification that should be made on the stove.

3.6 Health Impact of the Methanol Stove and Fuel Cooking Technology in the Homes

Table 12: Stove users' impression about the health impact of the methanol cooking technology in their homes

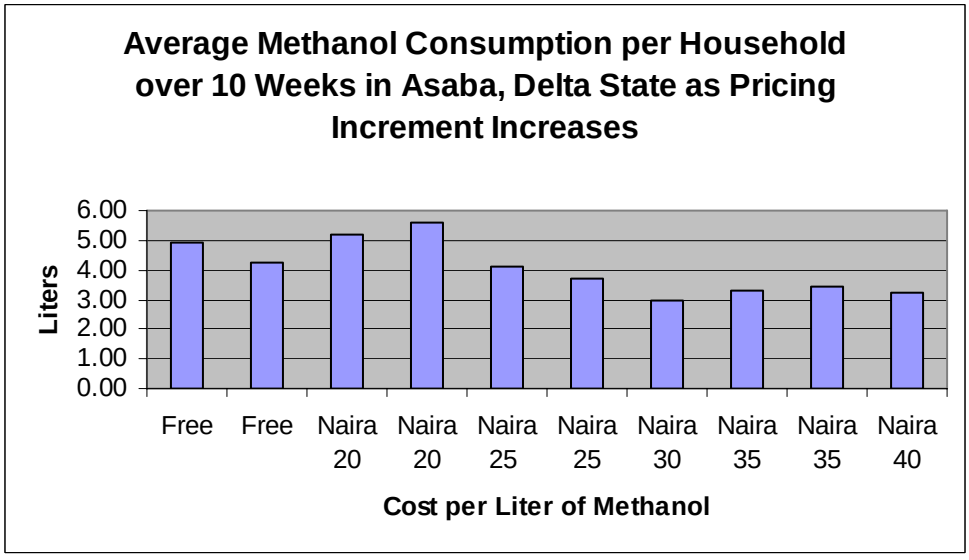
Response	Asaba	Warri	Abraka	Average%
Yes	89	92	94	91.7
No	11	7	4	7.3
No Response	-	1	2	1



When the study respondents were asked: "Has the CleanCook stove improved the indoor air quality in your home?" 89% of the respondents in Asaba said "Yes". In Warri, 92% said the CleanCook stove did improve indoor air quality (IAQ) in their homes. In Abraka 94% answered "Yes" to the question. However, those that said "No" to the question in Asaba were 11%. In Warri, 7% said the CleanCook stove did not improve indoor air quality in their homes. This answer was corroborated by 4% of the respondents in Abraka. While no respondent abstained from giving any answer in Asaba, 1% failed to respond to the question in Warri. In Abraka, 2% had nothing to say about the question. Taken together, about 92% of the study participants agreed that the methanol stove and fuel technology did improve indoor air quality in their homes.

4.0 Amount of Methanol Consumed Per Week during the Pilot Study

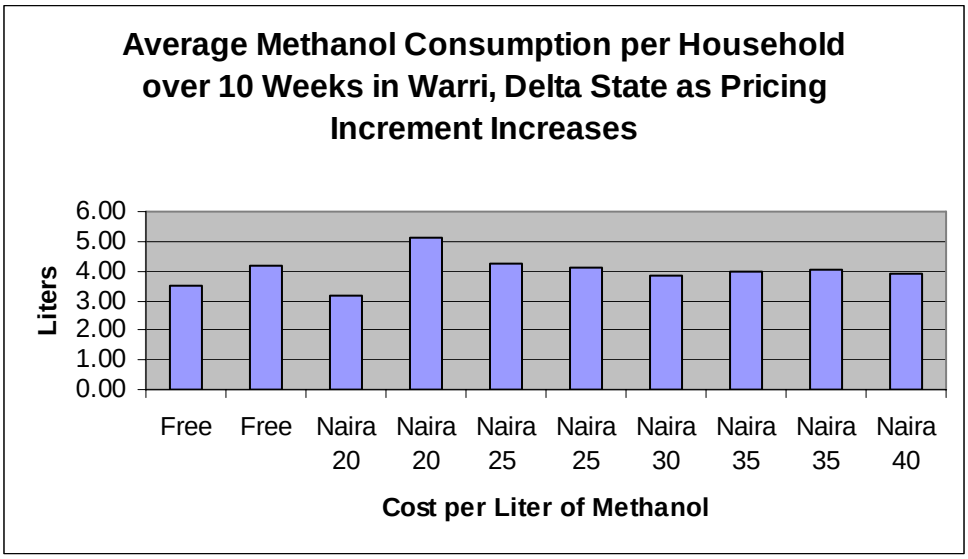
Table 13



As shown in table 13 above, pricing did not so much influence the demand for methanol in Asaba pilot study location. More demand was made when households started paying for fuel than when it was freely obtained. Although there was an initial

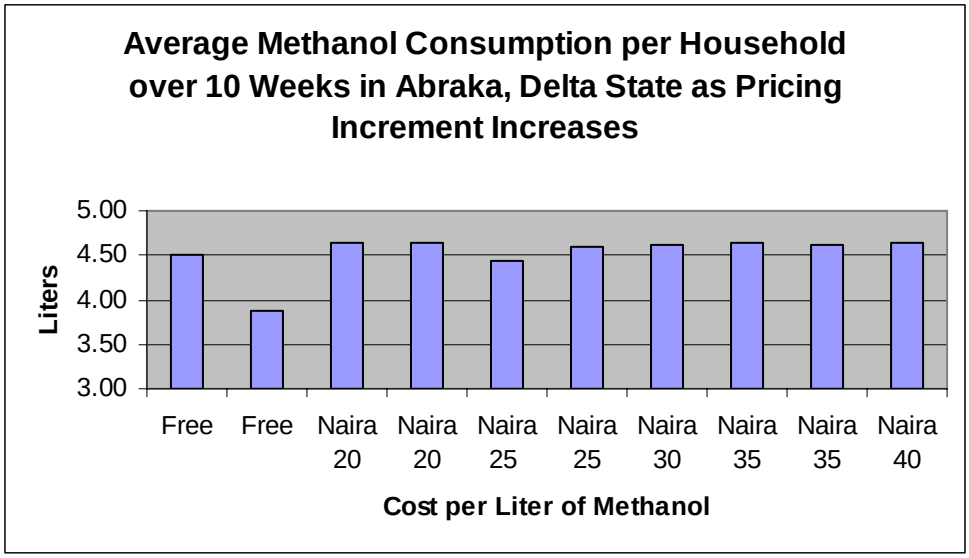
drop in demand following pricing increment, demand was to increase as pricing increased towards the end of the study. The reason for this was that by the 7th week, households had accustomed themselves to the quality of the new cooking technology to the extent that pricing increment did not so much influence their demand for fuel during the following 3 weeks.

Table 14



The demand for methanol increased dramatically in Warri irrespective of pricing increment after the first 3 weeks of trial by the participants (Table 14). During the first week of free methanol supply, an average of 4 litres of methanol was used in each home. One expected this trend to be on gradual decline as pricing increased. However, the demand for methanol was stepped up from week 4 when a litre was purchased for ₦20. This trend was maintained throughout the 10 week period with demand remaining constant when methanol pricing increased from ₦35 in the 7th week through ₦40, the highest amount charged for a litre of methanol during the pilot study. Demand was low initially even when methanol was freely supplied. Users apparently wanted to familiarize with the stove and fuel. Once the stove had been tested after the first 3 weeks, the pricing increment did not affect the demand of fuel negatively; rather more purchase was made as pricing increased. This trend gave credence to the extent to which the consumers were satisfied with the quality of the stove and fuel.

Table 15



Methanol consumption trend in Abraka pilot study location (Table 15) presents a unique feature given that more quantity of methanol was demanded and consumed as price per litre increased over the 10 week duration. The only time demand for methanol dropped was during the 2nd week of free supply. From the 3rd week, when households started paying ₦20 for a litre of methanol, demand remained constant up to the 5th week that recorded a slight drop in demand. From the 5th week on to the 10th week, demand for methanol maintained a constant appreciation notwithstanding the pricing increment.

5.0 Discussion of Results

As shown in Tables 1-7, the variables considered in analyzing the acceptability of the CleanCook stove and methanol as a cooking fuel were: overall safety of methanol as a cooking fuel; safety of methanol compared to the safety of kerosene, fuelwood and LPG; overall quality of methanol as a cooking fuel; CleanCook stove efficiency and performance; CleanCook stove fuel economy compared to other stoves; the use of kerosene stove during the pilot study and general users' satisfaction with the methanol stove.

Having tested the new cooking technology over a 10-week period, 97% of the survey respondents across the entire pilot locations agreed that methanol was a very safe fuel that can be used to cook in the CleanCook stove. This overwhelming response was only countered by the 3% of the survey respondents that held a contrary view that methanol was not a safe fuel to be used for household cooking. The view held by 97% of the respondents, who rated methanol as a very safe fuel, is corroborated by the fact that no accident in form of any injuries, burns and explosions occurred during the over 20,000 stove test days that the survey team logged in conducting the pilot study.

Across the entire pilot study locations, as seen in Table 2, a significant number of the respondents rated the safety of methanol fuel far above that of fuelwood, LPG and kerosene, the most common fuel and its stove used by a majority of the families. This

safety rating that favours methanol fuel over the others could have been prompted by the incessant cases of deaths and injuries from kerosene explosions that are prevalent in Delta State. It is not a surprise that a stove that cannot be made to explode under any circumstances could earn such an excellent safety rating from users.

When quality indicators like ease of lighting, safety, efficiency and performance were taken into consideration, nearly 95% of the survey groups rated methanol as a high quality fuel This result suggests that the CleanCook stove and its methanol fuel are the obvious choices of families in Delta State, where the use of quality cooking fuel and stove is grossly limited by perennial scarcity, high cost of fuel and poor safety records of existing fuels and stoves.

On the issue of fuel economy, 64% of the survey respondents considered the fuel economy of the CleanCook stove better than that of other stoves they were used to. 36% of the respondents, however, disagreed with this result hinging their view on the frequency with which the fuel runs out sometimes in the middle of cooking. Average methanol consumption per middle income household stood at about 26 litres per month at the time of the pilot study and given that a middle income household uses about 30 litres of kerosene per month in Nigeria from our findings during baseline survey, it is therefore right to consider the fuel economy of the CleanCook stove and its methanol fuel more efficient than that of kerosene stoves.

The opinion held by the 36% of the respondents who cited the frequency with which methanol gets exhausted when cooking is supported by 55% of the entire survey respondents who prefer the CleanCook stove to have two large capacity canisters that can each absorb up to 2 litres of fuel and last up to 10 hours of continuous cooking, as against the present canisters that last for 8 hours. Overall, respondents prefer the CleanCook stove to have large capacity fuel canisters than the other accessories like more burners; stove built on stand and fixed pot support, which was the next choice to large capacity canisters with regards to suggestions on modification to be made to the CleanCook stove.

As shown in Table 6, the few respondents totaling 11% that used kerosene stove during the pilot study did so only when they ran out of methanol. This suggests that methanol fuel would completely replace kerosene stove if its availability is sustained without the supply disruptions associated with kerosene. This result gives credence to the argument for outright local production of stove and methanol in other to ensure affordability and sustainability of supply. Besides the unwholesome problem of adulteration, the other major problem that has hampered the use of kerosene is perennial short fall in supply. This is one issue that any commercialization effort of the CleanCook and methanol fuel must try to avoid.

The result in Table 6 also suggests that methanol fuel would potentially replace kerosene in the Nigerian market if its availability is guaranteed from the outset of commercialization. This again underscores the need to develop the business plan around local manufacture of the CleanCook stove and fuel.

Data obtained on the willingness of the respondents to pay for both stove and fuel in relation to the amount of methanol consumed across the entire pilot study location

indicate an overwhelming desire to have a quality, clean and efficient cooking technology if it is priced within consumers' disposable income. It is worthy of note that the willingness to pay result defied the traditional theory of demand, which is always negatively related to price *ceteris paribus* (Koutsoyainnis 1979). In other words, price is the sole determinant of demand in any free market economy. Although Willingness to Pay data show consumers' benchmark of almost ₦40 per litre of methanol and ₦5000 for the two-burner CleanCook stove, daily demand for methanol, as shown in Tables 13 – 15, indicates consumers' willingness to pay more for fuel irrespective of pricing increment. Consumers' desire to purchase fuel across the entire pilot study location was not affected by pricing increment. Rather, more quantity of fuel was demanded as price per litre increased.

Kerosene is currently priced differently in the two distinct markets that exist for the product in Nigeria. While it is officially sold for about ₦60 a litre *(hardly ever sourced at this price, though)*, it is occasionally available at ₦100 per litre in the unofficial market, where the bulk of kerosene is mostly available in Nigeria. Methanol for cooking could find a realistic price in between the prevailing prices in the official and unofficial kerosene market.

Regarding methanol distribution method, survey data show a seeming divided opinion among the respondents. While 52.3% of the entire study respondents agreed with the way methanol fuel was distributed to them in the stove canisters, 43.7% disagreed, saying they are not satisfied with canister distribution. Determined to get specific response regarding their most preferred choice of methanol distribution, respondents were further given the following options to choose from: refillable plastic bottles, stove canisters, graduated jerry cans and sachets. Again, their obvious choices were almost equally divided between the refillable plastic bottle option and that of stove canisters. Results obtained were 35.7% for methanol distribution in refillable plastic bottles and 40% for methanol distribution in stove canisters. So the latter choice prevailed among the respondents.

Moreover, the splendid quality of the design of the CleanCook stove presents an opportunity to distribute denatured methanol directly in the canisters to ensure that users do not come in contact with the fuel at all times. The stove canisters are uniquely designed in a way that methanol, once poured into the canisters, can neither spill nor explode but only comes into use by evaporative means inside the stove burning chambers when it is needed to burn. Methanol consumption data further show that a litre of fuel was just enough to cook by a family per day, which translates to 7 litres per week. This justifies a distribution model that would have the consumer making a start up acquisition of seven fuel canisters that could either be taken daily or weekly to a certified fuel dealer to drop off any spent canisters for refilled ones. Fuel would be sold on a tare or weight basis much like the way LPG is currently sold, but with more extensive control and oversight on the part of the certified dealer.

Given the inherent nature of methanol, which must be kept out of harm's way, it therefore becomes absolutely expedient to stick to its delivery in the stove canisters as agreed by majority of the respondents, who had the privilege of learning about the physical and chemical nature of methanol from the surveyors prior to placement of stoves in their homes. The primary cook in one of Abraka survey households

CCDH/ABK/045, Mrs. Comfort Ayigbe, could not agree more with the option of methanol distribution in the stove canisters. She cautioned the survey team that on no account should methanol be exposed in liquid, given that her 4- year-old son was once a victim of accidental kerosene ingestion that was nearly fatal.

On the health impact of the methanol cooking technology in the study homes, data shown in Table 12 indicate that the use of the CleanCook stove in place of fuelwood and kerosene in 150 pilot study households resulted in improvements in indoor air quality (IAQ) as testified by about 92% of the respondents. The health implications of these improvements in IAQ are difficult to quantify, as the study did not collect any information on the participants' personal exposure or health status. Direct observations and perception of IAQ were, however, applied by the surveyors over the pilot study duration. These methods, although subject to empirical limitations, did reveal the perceptive impact of the methanol cooking technology on IAQ. Further research on the health implications of the improvements in IAQ cited by the respondents is advocated.

6.0 Conclusion

The outcome of the pilot study of the methanol-fueled CleanCook stove in 150 homes in Delta State has been positive. The stove and its methanol fuel were overwhelmingly accepted by almost all the respondents that participated in the study. Families were very pleased with the following attributes of the new cooking technology: quality of both stove and fuel; performance and efficiency of both stove and fuel; safety of both stove and fuel; fuel economy of fuel and stove as well as the way methanol fuel was distributed to them.

Results on the willingness of respondents to pay for both stove and fuel show a strong desire of families not only to pay a reasonable amount for fuel and stove, but also consumers' eagerness to switch over to the new cooking technology. These desires, however, did not come without a caveat: promoters must ensure adequate supply of methanol and stove at all times unlike the situation with kerosene, LPG and fuelwood that have been hampered by perennial scarcity besides other disadvantages.

Consumers' desire to pay a reasonable price for fuel methanol as shown in the pilot study results is to an extent dependent on their disposable income. In other words, an appropriate pricing for methanol should not exceed the upper limit (unofficial price) of current price of kerosene. Methanol, being a free market commodity that must be priced according to the vagaries of market forces, can only attract a reasonable price that the consumers anticipate when local production is guaranteed. This same assertion applies to the stove, making local production of both stove and fuel inevitable if business must attain its bottom line efficiency.

Be that as it may, the pilot study results have shown that clearly an entry point exists for the methanol fuel and CleanCook stove business in Delta State, and by extension, Nigeria. We therefore recommend that it is a business worth investing.

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Annexes

More Users' Comments on how to Improve the CleanCook

In addition to the CleanCook stove modification suggestions given by respondents as shown above, other comments about how the CleanCook stove could be further improved are listed below:

(a) The edges of the stove are too sharp and occasionally result to injuries;

(b) There are some difficulties placing round-bottom pot, especially the local earthenware pots on the pot support of the CleanCook stove;

(c) Oftentimes, it is almost impossible to extinguish flames with the stove regulators when the stove gets very hot following long period of use;

(d) It is often cumbersome to flip the stove over to retrieve canisters for refill in the middle of cooking when the stove gets very hot.