Project Gaia's Ethanol-fueled CleanCook Stove Initiative and its Impact on Traditional Cooking Fuels Used in Addis Ababa, Ethiopia

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11 May 2006

Introduction

Project Gaia (PG) embarked on an 18 month pilot study in Ethiopia investigating the marketability and consumer acceptance of the CleanCook (CC) stove and ethanol fuel in late 2004. Never before used as a kitchen energy fuel in Addis Ababa, liquid ethanol was made available to the project through an agreement with the state-owned Finchaa Sugar Company, one of four manufacturers in Ethiopia's emerging sugar industry. With funding from the Shell Foundation's Sustainable Energy Program to carry out the study, 850 CC stoves were purchased from Dometic, a Swedish company and world leader in alcohol appliances, to be used and tested throughout the country, with 500 stoves marked for Addis Ababa, and the remaining 350 in institutional settings, including UNHCR refugee camps.

The city of Addis Ababa consists of 10 sub-cities, each then broken into smaller administrative districts called *kebeles*. Under the direction of the kebele officials, 50 homes were selected from within only one kebele for each sub-city. From the 50 homes, an average of 12 homes was selected from the high income group, 23 from the middle income group, and 15 from the low income group. This breakdown was determined by kebele administrators and the Project Gaia team, using demographics, and assessing the perceived purchasing power for the stove and fuel combination within each income group.

Once in the homes, the stoves remained for 90 days. During the first month, ethanol was provided free of cost. At the start of month two, households paid 1.65 Birr per liter of ethanol. Month three incurred a cost of 2.25 Birr per liter of ethanol to the consumer. This staggered pricing mechanism was used to understand user willingness to pay for the fuel, which could be used to infer stove and fuel satisfaction. If households were willing to purchase the fuel at a higher cost, it is probable that they enjoyed and preferred using the CleanCook stove and ethanol fuel in their kitchens.

The purpose of this paper is to assess the findings of the Addis Ababa component of the study. First, traditional cooking fuels used in the city and their costs will be discussed at length. Second, an investigation into the amount of ethanol used by study households across high, middle and low income groups during the study will be examined. Third, an energy use profile of 10 households both before and during CC stove implementation will be provided, demonstrating the impact of the new fuel and kitchen technology on the use of traditional fuels. A summary and conclusions will finalize the report, with a projection of "next steps" to be included as a guide for bringing the ethanol-fueled CleanCook stove to the market of Addis Ababa, Ethiopia.

Traditional Cooking Fuels of Addis Ababa

The people of the capital city of Addis Ababa, Ethiopia utilize numerous fuels to meet their daily household cooking needs, ranging from the use of dung and wood in the lower income homes to kerosene across all income groups to LPG and electricity in the higher income homes. To gain a more informed understanding of the particular fuels and their costs, a field investigation in and around the urban area was conducted by Project Gaia. Additionally, the fuels and their costs were cross-analyzed with a series of surveys that were carried out by PG over the course of its 18 month, 500 home pilot study of the ethanol-fueled CleanCook stove that began in the city in late 2004. Specifically, traditional fuel consumption rates prior to introduction of the CC stove into the homes were used to provide an energy profile of the city, as of the final months of 2005.

A Wood-burning City. Any visitor to Addis will immediately notice great piles of wood stacked along the roadsides throughout the city. Charcoal stuffed in food-aid sacks is ubiquitous as well, leading one to believe that the city relies predominantly on wood to meet their household energy demands.

In addition to the piles of wood and sacks of charcoal, a quick trip to the mountains on the northern edge of the city would allow the visitor to see the eucalyptus leaf and wood

gathering women of Entoto. Every day up to a hundred or more women walk out from the city to the mountains to bring the fuel into the city markets. Bundles weighing up to 40 kg are not uncommon, and some women carry more on their backs as they come down the mountainous roads.

The Fuels and their Costs. A summary of findings from the cooking energy investigation shows that fourteen different fuels are used throughout the city. Fuel use and preference was directly linked to household income, though it was also found all income groups use kerosene and that nearly all households used more than one kind of fuel in the kitchen. An example of such is the use of the charcoal stove for coffee ceremony across all income levels. Coffee ceremony is a deeply cultural practice that occurs in every Ethiopian home almost every afternoon. High income families use the charcoal stove for roasting the coffee beans as would any low income family.

Traditional coffee ceremony in Ethiopia

The fourteen fuels and their purchasing costs are detailed below. The more commonly used fuels are described first, followed by the less-used fuels. The fuel choices of the higher income group are provided at the end of summary.

Fuelwood. Women and girls go into the hills and mountains around Addis Ababa to gather wood and either bring it to market or sell it on their own. The fuelwood is sold in four ways: cut and ready to be used, in bundles of 7 pieces a half meter in length, in 1 meter long logs about 20 cm in diameter, and in bundles of thin branches.

For the already cut wood, the seller first cuts a 3 meter long piece of wood into 3 pieces. The meter lengths are then each cut vertically into 5-8 cm thick pieces with an axe, 8 of these pieces comprising a bundle. The bundle of 8 pieces lasts for an average of 2 hours of continuous burning in a three stone stove. A bundle sells for 4 Birr (US$0.46) in the city center, 3.25 Birr (US$0.38) in the outlying neighborhoods, and 2.50 Birr (US$0.29) on the edge of the city.

The bundle with 7 pieces of wood that are typically a half meter in length and 5 cm in diameter is not found in the markets in the city center. They are more commonly found in neighborhood markets where they sell for 3 Birr (US$0.35) and in the outlying areas where the bundle sells for 2 Birr (US$0.23). This wood is usually brought in from the countryside on donkeys. The bundle burns for about an hour.

The one meter long, 20 cm diameter log is cut from a tree and usually brought in from the countryside. The buyer cuts the wood his/herself. If the wood from the log is used an average of 2 hours per day, it would last an average of 2 months when burned in a three stone stove. The log sells for 200 Birr (US$23.00) at the center of the town, 180 Birr (US$21.00) in the neighborhoods, and 120 Birr (US$14.00) on the edge of the city.

The bundle of branches consists of about 15 pieces of 0.5-0.8 meter long sticks. They are not sold in the city center. A bundle sells for between 1.50-2.00 Birr (US$0.17-0.23) in the neighborhood markets and on the edge of town.

Fuelwood is used for all cooking needs in Ethiopia; baking bread, cooking wat (sauce), meats, making coffee, making injera (traditional flat bread eaten at all meal times). The lower income families and the poorest people are the primary uses of fuelwood.

Eucalyptus Leaves. Eucalyptus leaves are carried to the markets on the backs of women where they are sold in bundles of two sizes: 3 m long branches tied in a 1 m diameter

bundle, and 1.5 m long branches tied in a 0.5 diameter bundle. The larger bundle sells for 15 Birr (US$1.73) in the city center, 11 Birr (US$1.27) in the neighborhoods, and 8 Birr (US$0.92) on the edge of town. The larger bundle burns for about 2 hours in a three stone stove.

The smaller bundle sells for 10 Birr (US$1.16) in the city center, 7 Birr (US$0.81) in the neighborhoods, and 4 Birr (US$0.46) on the edge of the city. The smaller bundle burns for an hour.

Charcoal. Charcoal is made from three different trees that produce varying degrees of quality. All 3 types are sold throughout the city. The best quality charcoal is made from the olive tree, followed by the eucalyptus tree, with charcoal made from the tid tree being of the lowest quality.

Charcoal is sold in three ways: 50 kg sack, 30 kg sack, and a small 1 kg plastic bag commonly found at any shop throughout the city. The breakdown of charcoal quality, and costs in reference to location in the city is given below. The first number is cost in Birr, and the number in parentheses is the amount in USD.

**50 kg sack

	Olive Tree	Eucalyptus Tree	Tid Tree
City center	75 (8.67)	60 (6.94)	50 (5.78)
Neighborhoods	60 (6.94)	50 (5.78)	40 (4.62)
Edge of town	40 (4.62)	30 (3.47)	20 (2.31)

**30kg sack

	Olive Tree	Eucalyptus Tree	Tid Tree
City center	40 (4.62)	30 (3.47)	25 (2.89)
Neighborhoods	30 (3.47)	25 (2.89)	15 (1.73)
Edge of town	20 (2.31)	15 (1.73)	10 (1.16)

1 kg plastic bags of charcoal

The small 1 kg plastic bag of charcoal, which is enough for one coffee ceremony, lasts for 2 hours. It sells for 1 Birr (US$0.12), but the amount inside may actually be more

than a kg the further you go from the city center. Of note, charcoal's burn time varies depending upon the quality and the way it is burned. Aside from cooking, another use for charcoal is for warming rooms in the house during the rainy season.

Dung. Dung is made from cattle's waste. Generally it is found in places where cattle are, but there are people who bring dung in from countryside by donkey load. The shape of dung is oval like an egg, but flat. It is brown in color and its size is about 40 cm long by 20cm wide. Dung is used as an additional fuel with fuelwood or leaves. It is especially used for baking the traditional bread called *diffo* on holidays and other special days. It is not used alone for cooking. Dung is available for one Birr (US$0.12) everywhere, differing only in the number of dung patties dependent upon location. In the center of town, one Birr buys 4 patties, in the neighborhoods you get 5 patties, and on the edge of town one Birr buys 7 patties. As an additive fuel it is difficult to make any suggestions about its burn time. However, 5 dung patties burned with 8 pieces of 1 m long fuelwood bake one *diffo*, which takes an average of 2.5 hours. It is the lowest income homes that use dung on a regular basis.

Charcoal and dung patties

Donkey loads of dung patties

Sawdust. Sawdust is another additive fuel, but it is sometimes used alone, most notably for baking the flat bread *injera*. It is a waste product of the wood factories in the city. A 100 kg sack sells for an average price of 7 Birr (US$0.81). When burned alone, sawdust can bake *injera* for a 2 hour time period, using half of the sack.

Agri-residue. Agri-residue is rarely used in the city. It is used in the countryside where there is farming. It gives off a very small amount of heat.

Roots. Roots are not typically for sale. People living in the outlying areas use roots for making charcoal because it is more efficient to use it as a charcoal.

Barks, Leaves, Twigs (BLT). BLT is sold in a sack. Usually it comes from outside of the town. A sack sells for 8 Birr (US$0.92) in the city center, 6 Birr (US$0.69) in the neighborhoods, and 4 Birr (US$0.46) in the outlying areas. Its most common use is *injera* baking.

In some poor areas, BLT is sold for 1 Birr (US$0.12), and even this is divided into ten pieces that are sold for 0.10 Birr (US$0.01) each. The heat output is very small.

Making small pieces of charcoal

Tiftif. Tiftif is a kind of dung but it is made from charcoal powder, ash, some dung and a small amount of soil mixed with water. It is place in the sun for drying. It has circular shape with a diameter of about 20 cm. When it dries it is used the same way charcoal is used in a charcoal stove. Its heat output is not quite as strong as that of charcoal. The price of 2 pieces of tiftif, the least quantity you can buy, is 0.30 Birr (US$0.03) in the city center, 0.25 Birr (US$0.028) in the neighborhoods, and 0.20 Birr (US$0.023) on the city's edge.

LPG. Several different companies sell LPG in the city, but the prices are almost identical. Some of the companies are: Wajag, Gion, Shell, and Agip. The price depends on weight and is the same price in every part of the town.

Weight	Birr	USD
2 kg sold with stove at the top of the cylinder	156	18.00
4 kg sold with stove at the top of the cylinder	216	25.00
11 kg without stove	108	12.50
12 kg without stove	115	13.30

A two burner stove sells for 143 Birr (US$16.53). A three burner stove sells for 165 Birr (US$19.08). The fuel is used by the upper middle class and above.

Electricity. Electricity is the most valuable and expensive fuel used in the town. The electric line is bought from the Ethiopian electric power authority and consumers are charged a monthly consumption fee. The price for consumption depends on the number of kw used per month. The greater the number of kw used, the higher the price per kw. An 11.19 Birr (US$1.29) tax is assessed each month as well.

01kw - 50kw ---------- Birr 0.27 per kw
51kw - 100kw---------- Birr 0.29 per kw
101kw - 200kw ---------- Birr 0.41 per kw

201kw - 300kw ---------- Birr 0.45 per kw
301kw - 400kw ---------- Birr 0.46 per kw
401kw - 500kw ---------- Birr 0.48 per kw

Biogas. Biogas is not for sale in the city. Some people use it in homemade stoves, and big organizations, e.g charity homes and prisons, use it for cooking.

Kerosene. Kerosene is used in almost every home in the city, no matter the income level. Some people use kerosene everyday and some use it sparingly. It is sold in gas stations only, and its price is the same in every station, no matter its location in the city. The recent price per liter of kerosene is around 3.00 Birr (US$0.35).

The Addis Ababa Pilot Study

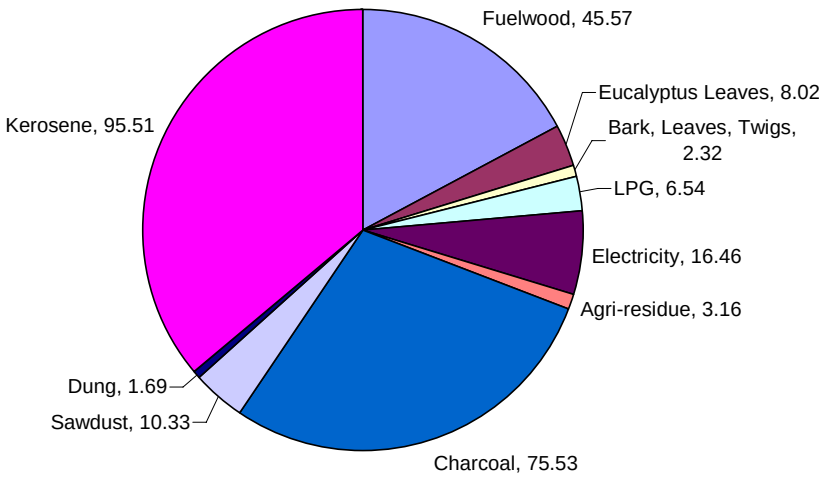
At the outset of the pilot study, Project Gaia assessed the cooking fuels used in the households of Addis Ababa. The Baseline Survey asked residents to detail typical cooking habits in their homes at the current time in relation to the various fuels used to prepare a week's meals. Respondents could provide as many different fuels as they wanted, and were asked to give an estimate of how much of each fuel is used each week or month.

Results from the baseline survey (see chart below) show that Kerosene is the most widely used fuel in Addis Ababa, followed by Charcoal and Fuelwood respectively. Dung, Agri-residue, Sawdust, Eucalyptus Leaves, Bark-Leaves-Twigs, LPG, and Electricity play lesser roles in meeting cooking demands.

The elevated use of Kerosene in the city can be attributed to the fact that it is easily available and is relatively affordable, as it is subsidized by the government, though over the past couple of months the price per liter has risen above 3.00 Birr, adding to the challenge for many lower and middle income homes to reach their household energy needs.

Charcoal's ubiquity is directly related to the coffee ceremony, a daily occurrence in homes throughout Ethiopia where families prepare coffee in a time-honored tradition. Fuelwood is used primarily for baking *injera*, a flat-bread that is eaten with every meal throughout Ethiopia. Baked on a large pan over a woodstove, *injera* can be bought at local food markets, though many families prefer baking their own. Still, the *injera* for sale at local markets is often cooked on the woodstoves.

Household Cooking Fuels and Percentage Use in Addis Ababa, Ethiopia



Monthly consumption rates across all income levels show that despite Kerosene having the highest cost per unit in comparison to Fuelwood and Charcoal, it is the preferred cooking fuel in Addis (see table below).

Monthly Consumption and Costs of Household Cooking Fuels (474 Households across all Incomes), Addis Ababa, Ethiopia, 2005

	% of HHs	Total Quantity Used/all HHs/Month	Avg. Qty Used/HH/Month	Total Cost/all HHs/Month	Avg. Cost/HH/Month	Avg. Cost per Unit
Fuelwood	45.57	11092.82 kg	51.36 kg	9129.68 ETB	42.27 ETB	1.22 ETB/kg
Charcoal	75.53	17681.59 kg	49.39 kg	14732.68 ETB	41.15 ETB	1.20 ETB/kg
Kerosene	95.57	9913 liters	21.88 liters	24415.83 ETB	53.89 ETB	2.46 ETB/liter
Dung	1.69	505.63 kg	63.20 kg	146.33 ETB	18.29 ETB	3.46 ETB/kg
Agri-residue	3.16	2133.30 kg	142.22 kg	392.58 ETB	26.17 ETB	5.43 ETB/kg
Sawdust	10.33	6608.33 kg	134.86 kg	1525.00 ETB	31.12 ETB	4.33 ETB/kg
Eucalyptus Leaves	8.02	10,671 kg	280.82 kg	1233.00 ETB	32.45 ETB	8.65 ETB/kg
Bark, Leaves, Twigs	2.32	1307 kg	118.81 kg	548.00 ETB	49.81 ETB	2.39 ETB/kg
LPG	6.54					
Electricity	16.46					

Sawdust use is associated with baking the various breads that are commonly found in the city, especially during religious seasons. Dung, Agri-residue, Eucalyptus Leaves, and Bark-Leaves-Twigs are used mostly by the lower income groups, though it is not necessarily the most economical means for cooking. Higher costs per unit figures are common when having to buy in smaller quantities or piecemeal, a familiar practice to many low income residents who buy fuel when they have money to do so. Buying in bulk is not possible because of the higher up-front cost placed on the stack of wood, 50 kg sack of charcoal, or kerosene stove when it needs to be replaced every 6-9 months.

Electricity is used more for cooking than LPG. Further investigation into this finding should be undertaken. Is it because the higher income groups prefer electric stoves? Is electric more affordable than LPG, when combining energy unit cost and stove cost? Is it influenced by fear that pressurized canisters may malfunction and explode?

With an average monthly rate of 21.88 liters of kerosene being used per household, 96% of Addis families are spending approximately 54 Birr per month on kerosene alone. Slightly more is being spent per household per month on Fuelwood (62.70 Birr) and Charcoal (59.27 Birr), but in fewer total households. Couple these findings with the fact that 31% of households surveyed use a combination of Fuelwood, Charcoal and Kerosene, and other lesser used fuels, to meet their cooking needs, and, using the averages above, these households may be spending upwards of 176 Birr per month to pay for cooking fuel. Also, 40% of Addis households primarily use the combination of Kerosene and Charcoal for cooking, bringing their average monthly costs to 113 Birr.

The fuel combinations show that households meet their cooking needs with several fuels and stoves. A one stop fuel and stove, so to speak, does not exist. Moreover, the average Addis family is spending anywhere from 1300 Birr to 2100 Birr per year on cooking fuel.

Fuelwood, Charcoal and Kerosene In Perspective

An in depth look at the use of Fuelwood, Charcoal and Kerosene, the three most commonly used cooking fuels in Addis Ababa, shows that 31 households (6.54%) exclusively used only Charcoal or Kerosene to meet their cooking needs (see chart below). Every household that used Fuelwood also used at least one other fuel for cooking. Fuelwood was never the exclusive choice for cooking, perhaps suggesting that wood is used primarily for *injera* baking and as a secondary cooking source, and that other fuels are used primarily for cooking food.

The combination of Charcoal and Kerosene was more prevalent than any other two traditional fuel combinations. This is likely related to coffee ceremony and the use of kerosene as being economical and accessible throughout the city as a means for daily cooking.

The combination of all three fuels was also found to be nearly as common at the Charcoal/Kerosene combination. The lack of fuelwood in this comparison may suggest that the Charcoal/Kerosene families purchase *injera*. Also, while these fuels are the

primary sources of cooking energy, they are often supplemented by other cooking energy sources.

Clearly, kerosene is the most used cooking fuel in Addis. Either in combination with Charcoal and/or Fuelwood and with other fuels, or used alone, it is the primary cooking fuel choice in the city. In fact, a little over 5% of households rely exclusively on Kerosene for cooking in their homes (see chart below).

Household Cooking Habits for Fuelwood, Charcoal and Kerosene in Addis Ababa, Ethiopia, 2005

	Total # of HHs	Percentage of Total # of HHs
Use Fuelwood, Charcoal, and Kerosene (and may or may not use other fuels)	146	30.80
Use Fuelwood and Kerosene (and may or may not use other fuels)	58	12.24
Use Fuelwood and Charcoal (and may or may not use other fuels)	12	2.53
Use Charcoal and Kerosene (and may or may not use other fuels)	188	39.96
Use Fuelwood not in Combo with Kerosene and Charcoal (but can combo with other fuels) *	0	0
Use Kerosene not in Combo with Fuelwood and Charcoal (but can combo with other fuels)	42	8.86
Use Charcoal not in Combo with Fuelwood and Kerosene (but can combo with other fuels)	10	2.11
Exclusively Use Fuelwood for Cooking **	0	0
Exclusively Use Charcoal for Cooking	6	1.27
Exclusively Use Kerosene for Cooking	25	5.27

***** Every household that used Fuelwood also used Kerosene and/or Charcoal, and some used other fuels in addition to the Fuelwood/Kerosene and Fuelwood/Charcoal combinations found in the Baseline.

****** If Fuelwood was used for cooking, it was always used in combination with other fuels. Not one household relied exclusively on Fuelwood for cooking.

Ethanol use during the Study.

The table below details the combined amount of ethanol used for each income group over the course of the study, aggregately totaled across all sub-cities. Currently, fuel use data exists for 7 of the 10 sub-cities showing that the high and middle income groups have a greater purchasing power for ethanol than the low income group, using approximately 21 liters per month compared to the 17 liters per month average of the low income households.

Ethanol Fuel Use in Addis Ababa by Income, 7 of 10 Sub-cities

	High Income	Middle Income	Low Income
Number of Households	74	149	89
Total combined Liters Used over all Sub-cities	4788.2	9312.25	4520.54
Average Liters per Household over the Three Month Study Period for each Sub-city	64.71	62.5	50.79
Average Liters per Household per Month	21.57	20.83	16.93

If we place the ethanol used per household per month averages of the high and middle income groups alongside the 21.88 average liters of kerosene used per month per household from the Baseline survey, we see a mere identical use of the fuels. Does this indicate that ethanol could be a natural replacement for kerosene in the city?

Given the 17 liter per month average of the low income group, and the fact that the Baseline Survey found that 96% of households in Addis use kerosene as a cooking fuel, the purchasing power of the low income group should not be overlooked. If the low income group is using kerosene, and indeed it is, then it is within their means to also use ethanol, which would cost less per liter than kerosene, which may result in higher consumption rates of ethanol amongst the low income group.

Willingness to Pay per Liter of Ethanol by Income

High Income	Middle Income	Low Income
2.10 Birr	2.02 Birr	2.04 Birr

Every two weeks throughout the 3 month study in each sub-city, study households were asked what they would be willing to pay per liter of ethanol. On average, households showed a higher willingness to pay at the end of the three months versus the beginning of the study. This can be attributed to familiarity and satisfaction with the new stove and fuel as exposure to the stove and fuel combination increased over time. While lower than the current cost of kerosene, 3.00 + Birr per liter, it is within reason to suggest that consumers would be willing to pay more than the 2.00 + Birr per liter of ethanol averages given in the chart above. Again, during phase 3 of the pilot study, households purchased ethanol at 2.25 Birr per liter. It is plausible to consider that perhaps households felt they could maybe influence the cost of ethanol through the surveying process, offering lower willingness to pay rates than what may be true of their purchasing power. Were

households trying to lower the cost on a fuel they preferred using through the surveying technique?

Additionally, being that kerosene is imported and subsidized by the government, it is highly probable that locally-produced ethanol would never exceed the cost of kerosene, especially if a similar subsidy was passed on to the consumer of ethanol like that of kerosene. Many respondents answered the willingness to pay question by saying they would pay any price up to but not exceeding the price of kerosene.

The Impact of the Ethanol-fueled CC stove on Traditional Fuels.

To attain precise data regarding traditional fuel use and the impact of the ethanol-fueled CleanCook stove on traditional fuels, 10 homes were randomly selected from the three income groups. Fuel use prior to the placement of CC stove was recorded every day for one week. During month 2 of the 3 month study in the sub-city, fuel use was recorded again each day for one week. Households were instructed to cook with whatever stoves they wanted or needed to cook with for their meals during this second week of the study.

Impact of Ethanol-fueled CleanCook Stove on Traditional Fuel Use in Addis Ababa, Ethiopia, 2005

	Before CleanCook Stove		When CleanCook Stove in Use		
	Total Quantity Used	Total Cost (ETB)	Total Quantity Used	Total Cost (ETB)	Quantity Reduction
Kerosene	31.5 liters	94.50	1 liter	3.00	30.5 liters
Charcoal	96.5 kg	97.00	15 kg	27.00	81.5 kg
Fuelwood	44 kg	55.00	16 kg	17.00	28 kg
Sawdust	5 kg	3.00	0	0.00	5 kg
Dung	25 kg	20.00	0	0.00	25 kg
Bark-Leaves-Twigs	2 kg	2.25	5 kg	10.00	+ 3kg *
Agri-residue	0	0.00	0	0.00	0
Eucalyptus Leaves	0	0.00	0	0.00	0
LPG	2 kg	12.00	0	0.00	2 kg
Electricity	0	0.00	0	0.00	0

***One family used Bark-Leaves-Twigs to make additional bread and *injera* to compliment an increased amount of food that was cooked as a result of using the CleanCook Stove, thus demonstrating the social impact of a new technology in the kitchen.

At the end of the two week mini-study, it was evident that the CC stove had a major impact on the use of all traditional fuels in the households, most particularly on the use of kerosene. The reductions demonstrate that the traditional fuels were also being used for more than baking *injera* and for coffee ceremony. Less Charcoal and Fuelwood use after introduction of the CC stove suggests that the two fuels were also used for cooking daily meals. Or, it is possible that some families were able to use the CC stove for their coffee

ceremony? Reports from the field did relay this information back to Project Gaia, a finding that was not anticipated at the outset of the study.

Kerosene's reduction from 31.5 liters to 1 liter used in a week is most dramatic. Referring back to the near identical monthly averages for kerosene and ethanol use before and during CC stove introduction, it is evident that ethanol would replace kerosene if made available to the people of Addis.

If we allow that Fuelwood and Charcoal are used for cooking meals in addition to their cultural roles of *injera* baking and coffee ceremony, and because the fuel-use investigation above shows a reduction in use of these two fuels, the use of ethanol would prove to be more economical to Addis residents. Able to replace more than one traditional fuel, ethanol would bring the total cost of cooking fuel down because households would be able to meet cooking demands with a more efficient stove that does the tasks of several stoves for everyday cooking. Improved cooking times, a well-documented component of the study, and lower overall fuel costs would prove beneficial to all income levels.

Summary and Conclusions.

The city of Addis Ababa, Ethiopia relies heavily on kerosene to meet its household cooking energy needs. At the time of the Baseline Survey, the average price per liter of kerosene was 2.46 Birr. Today, kerosene is selling for a minimum of 3.00 Birr in the shops of Addis, and is sometimes costing more depending on where the consumer goes to buy their kerosene. A 0.51 Birr increase in homes that on average use nearly 22 liters of kerosene per month amounts to a minimum increase of 135 Birr per family annually. In households where income is quite limited, kerosene is becoming too costly as a daily means for cooking.

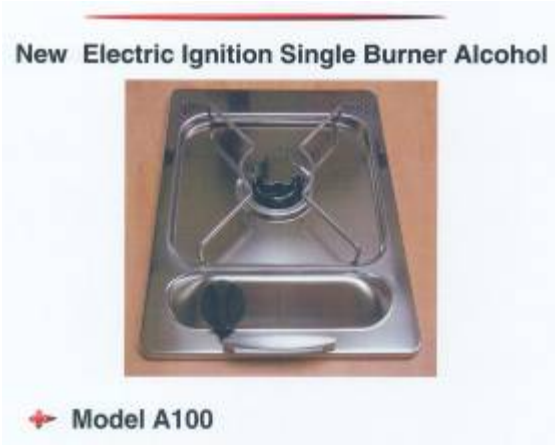
The impact of the CleanCook stove to reduce the dependence on kerosene is obvious. Not only is ethanol more affordable (2.25 Birr/liter), it is also locally-procured, thus a potential replacement for the state-subsidized, imported kerosene market. If the state were to place the kerosene subsidy on ethanol production, the cost to consumer would be very economical when compared to kerosene. And, ethanol is a less dangerous, cleaner-burning and healthier cooking fuel than kerosene.

Charcoal and fuelwood are also used in high quantities. The two-week, 10-home study indicates that the CC stove does impact the use of these fuels as well. Any reduction in the use of wood-fueled energy in the kitchen directly translates into an improvement in indoor air quality, a leading cause of death amongst women and children in the developing world. The impact of the ethanol-fueled CC stove also reaches the women and girls gathering wood in the mountains around Addis, resulting in fewer days missed at school, less physical ailments, reduced number of physical and sexual assaults, and more time pursuing personal interests and for spending time with friends and family. Further, less wood being burned in stoves throughout the city will lead to less cutting of wood, allowing the city's green cover to flourish and help lessen local air pollution caused by automobiles, factories, and common household cooking stoves.

Next Steps

The Project Gaia Team proposes to work with the government of the Municipality of Addis Ababa to explore the opportunity to design alcohol stoves suitable for use in the Municipality's condominium housing, as well as for a general retail market.

There is recognition, as a result of our pilot studies, that clean, odorless, safe alcohol fuels would be far superior for use in condominium housing than kerosene cookers and fuel. In addition to being dirty, kerosene cookers create risk of fire and explosion. Thus far, during more than 85,000 stove test days, not a single accident or mishap has occurred with the extremely safe Dometic CleanCook stove. This stove could be ideal for Addis Ababa's condominium housing.



Shown to the right are two existing models of the Dometic alcohol stove. The first image shows a counter-mounted alcohol-only one-burner stove. This stove lifts up at the front to receive the standard Dometic fuel canister, which is refillable and which holds a day's worth of alcohol cooking fuel at each filling. The second image shows a combination alcohol/electric two-burner stove that may be operated with alcohol fuel or with electricity. Thus, when electricity is not available or its use not desired, the stove may be operated as the one above, with alcohol fuel. These counter-mounted stoves are examples of the type of stove that could be adapted or designed for use in the new condominium housing of Addis Ababa.

The Gaia Association would be most happy to facilitate a working partnership among the Municipality, Dometic AB and its Ethiopian agent, Makobu Enterprises PLC, to advance the concept of developing alcohol-powered stoves for the Municipality of Addis Ababa and its condominium developments. This partnership would build upon the partnership already established as a result of the cooperative effort between the Municipality and Project Gaia to conduct the pilot study.

Under the right conditions, alcohol fuels have the potential to be *the cheapest improved fuel* to be available to the people of Addis Ababa. Current market price for alcohol fuel at Finchaa Sugar Factory is 2.17 ETB per liter. Latest projected price for kerosene in Addis Ababa markets is 3.45 ETB, with the phase-out in kerosene subsidy likely to push the price of kerosene up to as high as 4 ETB per liter. If ethanol supply and distribution

issues are worked out, ethanol fuel could be delivered to the Addis Ababa market at well under current and projected kerosene prices.

As the fuels study in this report has shown, the price of solid and unimproved fuels, such as charcoal and fuelwood, may well exceed the price of alcohol fuel, especially as wood and charcoal supplies become increasingly constrained. When solid fuels are purchased rather than gathered, they are not cheap; when they are gathered, they require time consuming and back breaking labor which itself must be given a value. Thus, alcohol fuels, if developed properly, could in the mid and even the short term, prove to be *the cheapest fuel* available to the consumers of Addis Ababa.

There are many hidden costs to using dirty and inferior fuels. These are social and environmental costs. Not the least of the social costs is the burden of respiratory disease placed upon the people of Addis Ababa by breathing smoke from kerosene and solid fuel cooking fires. (Additional information on our Indoor Air Quality testing and the beneficial impact of clean alcohol fuels is available upon request.) These hidden costs are often not quantified and certainly not quantified in the purchase price of fuels. Yet, these are real costs to the people of Addis Ababa and to Ethiopians. Viewed in this larger context of market cost *plus hidden costs*, alcohol fuels have the potential to become the cheapest fuel for household use *by a very wide margin*.

Project Gaia would like to work with the Municipality of Addis Ababa and with the Ministry of Mines and Energy to develop the potential of alcohol fuels for the great city of Addis Ababa, and indeed for all of Ethiopia.

Shown here is the standard fuel canister that operates in the stove, in space heaters and in ovens. A typical Dometic oven is shown to the right. By working together, the Municipality of Addis Ababa, the Ministry of Mines and Energy and Dometic, with its Ethiopian agent Makobu, may be able to design a range of appliances particularly appropriate for the consumers of Addis Ababa.

Going Beyond the Surveys.

More often than not, studies of this nature often overlook a key factor of its success or failure: perception. Sometimes numbers and data analysis are not able to speak to the project's real impact, as felt by the very people who are proposed as being the beneficiaries of the project's aim or goal. The following is an attempt to bring life into this report, to go beyond the numbers to gain an understanding of how the CleanCook stove and ethanol are affecting the livelihoods of the people of Addis.

These quotations have been taken from some of our pilot study reports:

"Before, I used the China Kerosene Stove and Charcoal Stoves. I used the former one [kerosene] because it was fast, and I preferred the charcoal stove when I prepare coffee because it is slow. But now, I use the CleanCook Stove for both, because I can make it cook fast and adjust it to cook slow. So I like the CleanCook because it substitutes the previous stoves that I used before." --Getenesh

"After I turn on the CleanCook Stove, I can put the pots on the stove immediately because it has no smell. But the charcoal stove has smoke when I light the stove; after the smoke dissipates, I put the pots on the stove. Another problem with the charcoal stove is that it takes too much time to prepare meals... The CC Stove is efficient; it has no smoke like the kerosene stoves. I hate the kerosene stoves. When I was pregnant, I hated the smell of the smoke of kerosene stoves, and no kerosene is in my home since I was pregnant. Before the CC Stove, I used only the charcoal stoves." --Aster

"It saves me time and allows me to be involved in different activities within my home. Because it has 2 burners, it helps me to prepare more than one food at a time. This alone allows me to be involved in various income generating activities outside the home. For example, I do laundry outside of the home as a means of generating income. I also spend this extra time caring for my 2 children." --Almaz