"Tapping the Potential of *Proalcool* for the Household Energy Sector"
Shell Foundation Project # 21316

Results of Project Gaia's 100 CleanCook Stove Pilot Study
Minas Gerais State, Brazil

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1.0 Introduction and Community Selection

The pilot phase of Project Gaia in Brazil began its field implementation in July of 2005 with the following immediate objectives: a) to install Clean Cook ethanol stoves in 100 households throughout Minas Gerais state, b) to assess user acceptance of the stove and fuel in rural and urban households by measuring, among other factors, perceived and actual stove/fuel safety, ease of use, convenience, appearance, cleanliness, and overall performance in fuel consumption economics. Long term objectives included: to understand the feasibility of rural, community-based cooperatives or associations in manufacturing and supplying their own ethanol to fuel the stoves through the use of microdistilleries, and to evaluate the stove's potential impact on local cutting of wood for cooking fuel and in reduction of indoor air pollution.

At the outset, the Project Gaia team in Brazil had decided to install the pilot households in communities near an ethanol distillery, so as to have a guaranteed fuel supply at lower prices than having to buy ethanol from fuel stations. The reason for doing so was directly related to the increasing high ethanol prices that were affected by several months of escalating petroleum prices. Ethanol fuel in Brazil today is linked to the gasoline market price, since ethanol is a competing fuel with gasoline in Brazil.

When the Project Gaia team proposed this project to Shell Foundation Back in 2004, the price of oil in the international market was about US$ 30 per barrel, while at the time of implementation of the project in Brazil, oil prices were above US$ 60 per barrel.

Ethanol distilleries in Brazil today have 3 primary positive options to market its produced sugar cane:

- First, distilleries make ethanol for the domestic fuel market, which has grown substantially since 2003 with the introduction of the flex-fuel[1] cars in the market. In 2003 just 10% of the near 2 million new cars sold annually in Brazil were flex-fuel, while in 2006 it is above 90%. These new flex-fuel cars contributed to the increase in the price of ethanol; given the higher prices for gasoline in Brazil, flex-fuel owners switched to ethanol[2]. As a result ethanol already represents about 40% of the gasoline fuel market today. Therefore there was a substantial increased demand in the domestic market, which inflated ethanol prices.
- Second, with the significant increase in the oil prices internationally, there was an increased global demand in ethanol for blending. Ethanol ranged from 2 to 10% of the composition of the gasoline/ethanol fuel blend in several countries worldwide. Brazil, being the main ethanol exporter in the world, of course benefited from this, which, as a result, added pressure on the Brazilian production capacity and led to inflated prices.

[1] Flex-Fuel cars are cars that can use any combination of ethanol-gasoline mix, from 0 to 100% of any of these fuels.

[2] Ethanol is a competitive fuel with gasoline when its price per liter is not above 70% of the price of gasoline, since in terms of overall fuel consumption, ethanol engines use 30% more fuel (per liter) than gasoline. The ethanol price must be 70% of the gasoline price to be economically equal.

- Third, the international market price for raw sugar also increased significantly, giving the sugar cane producer another product with a high rate of return.

Therefore, with higher prices for ethanol at the commercial fuel stations in Brazil, Project Gaia team decided to establish the project in communities where there would be a possibility to have less dependency on higher priced ethanol from gas stations, e.g. near an ethanol distillery that could supply ethanol at a much lower price. For this reason, Project Gaia Field Manager Regina Couto, in coordination with Winrock International advisors (Rogerio Miranda and Andre Oliver), followed leads of 12 potential communities meeting these requirements within Minas Gerais. One community was located near a large distillery and the 11 others were near a micro-distillery. After a careful review of these communities, and evaluating positives and negatives aspects for each community, including site visits, the team decided on the following communities:

- Dom Orione, Betim: A rural community of 39 families near Belo Horizonte, where there was an Ethanol Micro-Distillery (EMD). This community was created from an agrarian reform settlement, and each family cultivated the land with different products (fruits, vegetables, grains, sugar cane, pasture, etc). There is a smaller group of 28 families who own an EMD, which were then the total number of families that participated in the stoves project. The reasons for selecting this community were (1) the existence of an EMD, (2) the fact that they are an organized rural community, and (3) the proximity of Betim to where Regina resides.

- Santo Antonio neighborhood, Salinas: An urban low income neighborhood of the city of Salinas, which is located in the northern part of Minas Gerais state (610 km north of Belo Horizonte). A total of 38 families and one children's day care center have tested the stoves. The reasons for selecting Santo Antonio were: near Salinas there were 2 operating EMD that could supply ethanol at a lower cost, the possibility of installing more EMD near the city in the future, and it is a region of Minas Gerais state with a lower score on the Human Development Index.

- Jatiboca sugar mill, Urucânia. A rural settlement owned by Jatiboca ethanol mill. Twenty of the families were selected to test the clean cook stove. The reasons for selecting Jatiboca were: the free ethanol fuel supplied by the ethanol mill for the duration of the pilot study, and the idea of establishing a relationship with the owner of the Jatiboca mill (Mr. Luiz Custodio Cotta Martins), who is the president of the Ethanol Mills Association of Minas Gerais state (SIAMIG).

The other nine communities were not selected mostly due to a lack of interest by the community or the fuel supplier, long distances between the community and nearest fuel supplier, and being very poor communities, among others. The process of site selection took several months because of the laborious task of searching for leads of potential communities.

The field testing of the CleanCook stoves began in early April of 2006, although the original plan was to start it back in the fourth quarter of 2005. The delay in field testing was attributed to the need to spend more time to appropriately select among the dozen potential communities, and also to wait for the next sugar cane harvest season which was scheduled to begin in June-July 2006.

During this period of waiting, the team began a long and bureaucratic process to import the 100 CleanCook stoves from South Africa. Also, they implemented a baseline data survey and conducted stove operation and safety trainings for each of the selected families.

For each community, a local assistant was hired and trained to facilitate weekly surveys, arrange fuel supplies to the families, and troubleshoot any problems that may arise.

2.0 Profile of the Study Sites

2.1 Dom Orione, Betim

Betim is one of the principal cities of the state of Minas Gerais, belonging to the metropolitan area of the state capital, Belo Horizonte, and is considered to have the second largest economy of the state, behind the state capital city of Minas Gerais. Well known around the world for its great industrial park, most notably for auto maker Fiat and Gabriel Passos Refinery, Betim attracts people from other parts of the state and country because of its better living conditions. As is common in metropolitan regions, Betim suffers from this rapid and disorganized population growth.

The borough of Dom Orione in the outlying area of the city has such conditions. Some of the families have been around for more than 15 years, and some 33 families received a parcel of land within the past 9 years. The families make a living from family farms, vegetables being the most common crops that are sold in the metropolitan region. The village received equipment from state and federal governments to make cachaça and rapadura, and they received equipment to produce alcohol similar to equipment that other boroughs have received. The families likely will be able to produce alcohol with the sugarcane harvest of 2007. They have set aside an area for sugarcane production.

Twenty eight families participated in the study. The majority of families live off of what they produce on their land. Near 45% of the residents have retirement income, and if we add in the number of people that receive a pension or government assistance, that number goes up to 57%.

Education levels of the head of household are: 25% no formal schooling, 53% received a basic education, and 22% completed high school.

Of the 28 study families, 18% are 2 person homes, 36% have 3-4 people in the home, 28% are 5-6 person homes, and the remaining 18% have 7 or more people living in the home.

Income levels are variable. The families do own their land and most make living from farming activities. From the interviews, 46% of families noted a retirement income, and in some cases, families stated they had wage earning jobs.

Using the Shell Foundation parameters, 32% of families lived on less than US$ 1.00/day, 47% on US$ 1.00-3.00/day, and 21% lived on more than US$ 3.00/day.

2.2 Bairro Santo Antonio, Salinas

Salinas is located in the northern region of the state of Minas Gerais in the semi-arid Valley of Jequitinhonha, a very well known area of poverty. Known as a city of small transport, Salinas is referenced as one of the interior cities for commercial and health services. Salinas is known around the world as the "Capital of Cachaça," a popular Brazilian liquor (hard rum) of high alcohol content. Many families make a living from producing cachaça.

For the production of quality artesian cachaça, which Salinas is renowned for, some of the distilled production is thrown out (around 20% of the "head" and approximately 10% of the "tail"). This residual part, if distilled again, in appropriate equipment, could produce alcohol.

Salinas was selected as one of the project sites, given that aside from being a lower income town with people using fuelwood and LPG, Salinas also has several cachaça producers and already has two private installed alcohol micro-distilleries (EMD). The idea was to have the alcohol produced in one of these EMD supplied to the project, or hope that new EMD could be installed in the near future, and potentially supply alcohol for the community.

Salinas is also home to the Federal Agrotécnica School of Salinas - EAFSAL, which offers the only course in the country on "Technology of Artesian Quality Cachaça." The directors of the EAFSAL were favorable to explore a potential partnership with Gaia project, to share the cost for an EMD within the EAFSAL compound.

The Municipal Government of Salinas provided the Gaia project with some initial support for the project, and indicated the Association of the Neighborhood of Santo Antonio as a study site, assisting with family selection. Bairro Santo Antonio is a poor urban community of Salinas located about 2 km from the city center. From the community, 38 families and 1 day care center were selected to participate in the study. Project Gaia was a factor in strengthening the Association; as a result of the study, more homes entered into the Association.

Regarding education levels in Santo Antonio about 25% of the participating families had no formal education, 65% had a basic education, and 10% completed high school.

Of the 38 participating families, 5% are 2 person homes, 40% are 3-4 person households, 45% are 5-6 person homes, and the remaining 10% have more than 7 people in the home.

In relation to income level, the majority of the families of Salinas do not have regular work, and their earnings are lower than minimum wage (R$350.00, US$ 120/month, TBC, April 2006). Many make a living with small and sporadic jobs, while some of the housewives make and sell biscuits and breads to raise the family income.

Most families do not have a fixed income. Using the Shell Foundation parameters, 45% of families live on less than US$ 1.00/day; 55% live on US$ 1.00-3.00/day, and none are in Segment 3, more than US$ 3.00/day. The families live very modestly in very simple homes, and some pay rent.

2.3 Usina de Jatiboca, Urucânia

The Jatiboca Sugar Company was founded in 1920 in the municipality of Urucânia situated near the city of Ponte Nova, some 200 km southeast of Belo Horizonte, which is the capital of the state of Minas Gerais.

Currently the company has capacity to produce about 1 million sacks of sugar and up to 32 million liters alcohol per year. It owns a total sugar cane planting area of 9000 ha and also rents another 2000 ha from third parties. It has 900 permanent employees, and more than 600 workers are contracted during the sugar cane harvest. During the last harvest (2005); 4,986,769 liters of hydrated alcohol was produced; 8,750,634 million liters of anhydrous alcohol was produced; and 984,149 fifty kg bags of sugar and 21,630,225 kg of molasses were produced.

The Company selected 20 families that work for them to participate in the Project Gaia pilot study, and donated 5 liters of ethanol/week for each family.

All the families live in homes owned by the Company in various communities in the area. Fifteen families live in rural villas at the entrance area to the company grounds, while four families are located about 30 km from the factory in the district of Ana Florencia. One family lives in the urban district of Cardosas. The majority of these families work on the sugarcane plantations, and not necessarily in the factory.

We partnered with the Jatiboca Sugar Company after being introduced to them by the President of Siamig (Sugar Companies Association of Minas Gerais), Mr. Luiz Custodio Cotta Martins, who is a shareholder with the Jatiboca Company. The superintendent of the Jatiboca Sugar Company is Mr. Moacir de Melo.

Regarding levels of education, we consulted the head of the family that works at the sugar company: 10% did not have a formal education, 70% had basic education, and 20% finished high school.

Of the 20 families participating in the pilot study, 50% have 3-4 people living in the home, 40% have 5-6 people, and 10% have more than 7 people living in the home.

Given that the families work for the sugar company, their income varies according to season. During the harvest, family income is higher, and is influenced by the size of the harvest. Also, more of the family members work during the harvest to increase the total family income. But, the vast majority of workers lives in company housing and are charged a very low rent from their salary by the company to pay for their housing.

Again using the following parameters established by Shell Foundation to determine living standards, we found in Jatiboca, 10% of families are in Segment 1, and 90% are in Segment 2. None are Segment 3 families. The families live modestly, despite seeing electronic appliances in their homes, e.g. TV, DVD player, refrigerator. Just one family does not possess a TV, due to evangelical religious reasons.

3.0 Baseline Survey

Before delivering the CleanCook stoves to the families, the Project Gaia team implemented a baseline survey in each community to gain an understanding of socioeconomic characteristics and cooking practices of each household. The socioeconomic findings from the baseline survey were detailed above. The following are the "cooking practices" findings from the baseline survey:

Table 3.1—Education Levels of Study Participants

Formal Education	Dom Orione	Santo Antonio	Jatiboca
None	25%	25%	10%
Basic education	53%	65%	70%
High school	22%	10%	20%

Table 3.2—Size of Study Households

Number of people at the household	Dom Orione	Santo Antonio	Jatiboca
Up to 2	18%	5%	0%
3 to 4	36%	40%	50%
5 to 6	28%	45%	40%
Above 7	18%	10%	10%

Table 3.3—Income Level of Study Households

Income level	Dom Orione	Santo Antonio	Jatiboca
Less than U$1 per person/day	32%	45%	10%
U$1 to U$3 per person/day	47%	55%	90%
Above U$3 per person/day	21%	0	0

Table 3.4—Cooking Stoves owned and used prior to CleanCook stove

Type of stoves used	Dom Orione (28 families)	Santo Antonio (39 families)	Jatiboca (20 families)
LPG stove ownership	89%	95%	100%
Wood stove ownership	71%	85%	80%
Combined usage, Wood and LPG	64%	85%	90%
Use only LPG stoves	25%	10%	10%
Use only wood stoves	11%	5%	0

Table 3.5—Overall Primary Cooking Stove Used prior to CleanCook stove

Primary Cooking Stove used in the Home	Betim – Dom Orione (28 families)	Salinas (39 families)	Usina Jatiboca (20 families)
LPG	71%	70%	60%
Wood	29%	30%	40%

Table 3.6—Fuelwood Collection in Study Homes

Fuelwood Collection	Dom Orione	Santo Antonio	Jatiboca
Collects fuelwood	68%	45%	80%
Average time	42 minutes	120 minutes	65 minutes*
Average distance	350 meters	1500 meters	1700 meters

*The shorter time is attributed to the fact that the employees of the sugar company leave the wood in areas of easy access, and then they gather it on Sundays to economize time.

Table 3.7—Purchased Cooking Fuels in Study Homes

Fuel Purchased	Dom Orione	Santo Antonio	Jatiboca
LPG canister (13kg)/R$ 35.00	89%	90%	100%
Fuelwood (wagon)/ R$ 25.00	0%	40%	10%

Table 3.8—Average LPG Fuel Duration (13 kg canister)

Duration of LPG	Dom Orione	Santo Antonio	Jatiboca
13 kg canister	57 days	42 days	60 days

Table 3.9—Cooking Times for LPG and Fuelwood

Average time used for cooking per day	Dom Orione	Santo Antonio	Jatiboca
LPG	1:55 hours	1:36 hours	1:40 hours
Fuelwood *	4:04 hours	4:23 hours	5:26 hours
(heat up hot water for shower)**	11%	25%	45%

* The wood stove is used for longer hours not because it takes longer to cook the same meal, but mostly because it takes longer to light it, so people keep it lit longer hours to prepare any food (usually coffee) without need to relight it, and also to produce enough hot water for the family shower when a serpentine coil is attached to the stove.

** Heating water for showers is done through a serpentine (water coil) in the wood stoves.

Surveying for the negative and positive impacts of their existing stoves during the baseline survey, in all three communities the families stated that the use of the wood stoves was influenced primarily by economic reasons; the majority that use fuelwood gather it and do not buy it. Many families noted that food cooked on woodstoves has a better taste. However, they pointed out smoke as a negative factor, and the difficulty to use it during the rainy season (wet fuelwood) was another common complaint of woodstoves. As for the LPG stoves, they prefer them mostly because of fast cooking times and fuel accessibility (home delivery system). However, they do consider LPG to be expensive.

As for health and safety, only 20% of the families complained about wood smoke in the baseline survey, since in general the areas in the houses where the wood stoves are located are relatively open. The most reported health problems associated with the wood

stove were eye irritation, respiratory infections, and back pain due to carrying heavy loads of fuelwood. No complaints about the safety of the wood stoves were reported, but 20% of the families did say that they feel unsafe with LPG bottles nearby.

4.0 Ethanol Supply during the Pilot Study

The fuel supply for Dom Orione was provided by the nearest fuel station because the several months' delayed start of the pilot study did not coincide with the sugar cane harvest of late June. San Antonio in Salinas also had the fuel supplied through a local fuel station for the same reason. Although the plan was to use locally available ethanol before the end of the field test, the timing of the locally procured fuel supply in both Dom Orione and Salinas did not happen, preventing Project Gaia from using locally produced ethanol and causing the team to rely on ethanol from fuel stations.

In June in Dom Orione there was an ownership dispute over the EMD (microdistillery). A community leader claimed that he brought the EMD to Dom Orione on behalf of MST (Movement of landless works), a powerful organized group in Brazil. The problem began when this leader was expelled from the community in May 2006 with charges of corruption. Consequently, he took revenge by taking the EMD with him. It was a sad moment for the community given that it involved bringing the police in to resolve the dispute. In the end the community lost the EMD, and, thus, the project lost the opportunity to use it. However the community has mobilized and solicited support from the federal government, which has promised to support Dom Orione to obtain a new EMD.

In Salinas the two EMD who promised to sell ethanol cheaper to the community were prevented in April 2006 from producing ethanol by the state environmental agency because their operations were not fully complying with environmental regulations. Therefore, the Santo Antonio community in Salinas was not able to use locally produced, cheaper ethanol, and so it continued to rely on the fuel station supply.

As per the project design, Project Gaia provided free fuel ethanol for Dom Orione and Santo Antonio communities for about 12 weeks. The proceeding 8 weeks utilized an incremental pricing scheme of the delivered ethanol until it reached the full market price of the nearby fuel stations for the purpose of determining user willingness to pay per liter of ethanol. In Jatiboca, the fuel was provided for free by the Jatiboca sugar mill since the first days of April, when the study began there.

In Santo Antonio and Jatiboca each family received 5 liters of ethanol per week, while in Dom Orione 61% received 5 liters per week, and 39% of the families received 7 liters per week (these families specifically requested more ethanol to adjust to their needs).

In Jatiboca the fuel was supplied by the ethanol mill from the first days of the study that began there in late April.

5.0 Results of CleanCook Stove and Ethanol use during Pilot Study

The field data collection period ended for Dom Orione and Santo Antonio in late August 2006, while Jatiboca data collection proceeded until the end of December 2006 because the Jatiboca Sugar Company decided to continue donating ethanol to the families.

The following are the main findings from the weekly surveys:

Table 5.1—Refilling Rates of Ethanol Fuel Canisters and Amount of Ethanol Consumed per Week

Frequency of refueling ethanol into the 2 stove canisters	Dom Orione	Santo Antonio	Jatiboca	Ideal Amount to be Consumed per week*
Every 2 days	29%	87%	11%	8.4 liters
Every 3 days	48%	12%	57%	5.6 liters
Every 4 days	14%	-	27%	4.2 liters
Other	9%	1%	5%	

*****Calculated according to frequency of refilling. Each canister holds 1.2 liters of ethanol.

Project beneficiary Morilia speaks about the CC stove while Regina Couto takes notes.

Morilia states, “I prefer cooking with the CC because it is safer than gas and just as fast. 4 of the 6 gas burners didn’t work, so the CC is the same for me [regarding burners].”

Table 5.2—Time CleanCook Stove in Use per Day

Time/day	Betim	Salinas	Jatiboca
Up to 60 minutes	3%	3%	27%
60 to 90 minutes	30%	79%	41%
91 to 120 minutes	29%	13%	19%
121 to 180 minutes	32%	2%	10%
More than 180 minutes	6%	3%	3%

Ms. Nelci has completely stopped using LPG. Before the CC, a 13 kg LPG tank lasted 30 days. If the unit price of ethanol and LPG were equal, Nelci says, "I would use CC because it cooks faster than LPG," explaining that the CC's flame is stronger than LPG's. CC is "the best stove." Before the CC, Nelci and her husband Joao collected wood every day for about 2-3 hours each time. Since the CC, they collect wood once/week for about 2-3 hours.

Table 5.3—Other Stoves Used during the Study

	Dom Orione	Salinas	Jatiboca
Stopped using wood	18%	25%	22%
Stopped using LPG	19%	5%	15%
Stopped using wood and LPG	7%	5%	11%
Diminished use of wood	62%	30%	19%
Diminished use of LPG	71%	50%	33%

One interesting observation is that the Brazilian cooking culture generally includes 3 to 4 different food items per meal, which requires more than 2 cooking burners to cook the meal. Given that the CleanCook stove model used in the study had only 2 cooking burners, the majority of the families complemented their cooking needs with another cook stove.

"Before, I used a lot of firewood, and now with the CC I have more time to do other things. The CC is much faster than the LPG stove. My kids and some neighbors come to my house to use the CC."

--Ms. Elza

Table 5.4—General Safety of CleanCook Stove

	Dom Orione	Salinas	Jatiboca
Very Safe	33%	25%	16 %
Safe	57%	75%	84%
Safer than LPG	72 %	76%	58%
Safer than woodstove	54%	71%	58%

The families reported to feel safe around the Clean Cook, mainly when children were in the households, as there is no risk of explosion due to fuel leakage or stove malfunction.

Table 5.5—Smoke Level of CleanCook Stove

	Dom Orione	Salinas	Jatiboca
CleanCook burns clean	71%	90%	95%
Burns cleaner or as clean as LPG	76%	95%	95%
Burns cleaner than woodstove	85%	100%	100%

Some families reported that the Clean Cook blackened their pots. This is attributed to denaturants (usually a small amount of kerosene or gasoline to render it unusable for making spirits) that are added to fuel ethanol sold at the pumps. However, the families

stated that it was not a problem for them, as they were accustomed to much worse blackened pots from use with the wood stoves, and the soot was easily removed from the pots.

Table 5.6—Positive Aspects of CleanCook Stove

	Dom Orione	Salinas	Jatiboca
Fast cooking	80%	71%	74%
Safety	65%	71%	42%
Easy to use	28%	5%	16%

Families were able to give more than one answer when asked about positive and negative aspects of the stoves therefore percentages exceed or may not add up to 100%. The most cited responses are provided. The same is true for the question regarding stove improvement. These were open-ended questions.

Table 5.7—Negative Aspects of CleanCook Stove

	Dom Orione	Salinas	Jatiboca
Not enough burners	12%	20%	30%
Not all pots fit on burner	19%	30%	26%
Dirties pot bottoms	9%	10%	11%
Difficult to clean, or light	9%	10%	11%
Price of ethanol	19%	55%	-

Table 5.8—Suggestions to Improve CleanCook Stove

	Dom Orione	Salinas	Jatiboca
More burners	9%	53%	35%
Secure pot supports	70%	68%	41%
Pot supports for smaller pots	-	35%	-
Additional oven	85%	6%	-
Built into a stand/table	45%	10%	15%

6.0 Ethanol Purchasing Power

Toward the end of the field trial, Project Gaia started to charge the families an incremental price for the ethanol being delivered. After using the ethanol for about 3 months free of charge, where the purpose was to evaluate their acceptance of the Clean Cook stove independent of the fuel price, a final assessment was carried out to determine willingness to pay for the ethanol. The cost of the delivered ethanol gradually increased until it reached the full local market price. Study participants in Jatiboca did not pay for ethanol, as it was donated by the local sugar company. The following tables demonstrate willingness to pay per liter of ethanol in Dom Orione, Betim, and Bairro Santo Antonio, Salinas:

Table 6.1—Homes that Purchased Ethanol in Dom Orione, Betim

Week/Price (Reais per liter)	1/R 0.50	2/R 0.50	3/R 1.00	4/R 1.50	5/R 1.80	6/R 1.80 *
Betim	86%	75%	75%	57%	36%	32%

* Price per liter of the ethanol sold at the nearest fuel station

Table 6.2—Homes that Purchased Ethanol in Bairro Santo Antonio, Salinas

Week/Price (Reais)	1/R 0.50	2/R 0.50	3/R 1.00	4/R 1.00	5/R 1.50	6/R 2.00	7/R 2.00*
Salinas	100%	95%	92%	90%	90%	79%	85%

* Price per liter of the ethanol sold at the nearest fuel station was R$ 2.42

As shown, the data from Dom Orione confirms that up to the price of R$ 1.00 there was still a significant proportion (75%) of the households that continued to use ethanol. Beyond R$ 1.00, it dropped as the pricing mechanism increased. However, it is very interesting that in Santo Antonio, although poorer than Dom Orione, the majority of the households continued to buy ethanol at higher prices. One justification for the continued used of ethanol in Santo Antonio is the fact that 40% of the households already buy fuelwood (in Dom Orione no one buys it). Also, the time and the effort for those who collect fuelwood in Santo Antonio are much higher than in Dom Orione.

Also, in Betim, the majority of families live on a fixed income and during the final two weeks of the study when households were to buy ethanol, the families were at the end of their month's pay and had little money left until they received their next pay check. Still, 2 of the families (7%) bought ethanol directly from the gas station because they needed more ethanol. In Salinas, the majority of families do not live on a fixed income. However, the families had set aside money as they earned it so they could buy the next allotment of ethanol when Project Gaia sold it to them.

6.1 Willingness to Pay per Liter of Ethanol

In Dom Orione, 66% of the families said that a fair price for the ethanol would be R$1,00 (U$0,45) per liter, while 51% said that the maximum price that they would be willing to pay was up to R$1,50 (U$0,68), and 28% said between R$1,50 and R$2,50 (U$1,14).

In Santo Antonio, 40% also said that a fair price would be up to R$1,00, while 45% said that the maximum price they would be willing to pay was up to R$1,50.

The families in Jatiboca received free ethanol from the sugar company during the study. When asked about a fair price to pay per liter of ethanol for cooking, 47% did not know how to answer the question, and many pointed out that there is no pump near where they

live. The other 53% of families said that a fair price would be between R$ 0.75-1.00. Of those 53%, 32% said they could likely afford to pay R$ 1.00/liter and 11% said they could perhaps pay R$ 1.20/liter of ethanol.

One key advantage of the Clean Cook is the possibility to buy the ethanol in small amounts, as noted by 60% of the families in Salinas. Given that the majority of the families do not have a steady income it is difficult for them to have the economic means for the bulk buy of an LPG cylinder whenever it runs out. Buying ethanol in small amounts is an option that the majority of households would be in favor of.

"If I can buy alcohol little by little in small amounts, it would be better for me…Sometimes I can't afford to buy the LPG tank. It's too much money. If the alcohol price goes lower, I will cook with the CC stove only."

--Ms. Gilza

At the end of the study, many families expressed interest in continuing to use the CC stove. To better understand willingness to pay for ethanol, those families that could afford to buy their own ethanol from the local pump maintained the stove. The families in Jatiboca were not given this option because they had received free ethanol for the duration of the study, and because they do not have a pump near where they lived. When queried, the Jatiboca families remarked that using the CC stove regularly would not be very likely to occur. The majority of families in Salinas decided to keep the stove for the primary reasons already sited above: less fuelwood available, and easier to buy ethanol per liter than LPG per 13 kg canister. A little over half of the Betim families decided to continue using the stove. Several families said that if the community produced its own ethanol, they would keep the stove in their kitchens.

Table 6.2—Continued Use of CC Stove at end of Pilot Study

	Dom Orione, Betim	**Santo Antonio, Salinas**
Families	53%	71%

7.0 Willingness to Pay for CleanCook Stove

Study participants were asked to consider what a fair price would be for the CleanCook stove, and they were asked how much they could actually afford to buy the CC stove. The findings per site are as follows:

Table 7.1—Dom Orione, Betim

Price(Reais)	Fair Price	Could Afford to Pay
Up to 50.00	27%	-
51.00 to 100.00	56%	3%
101.00 to 200.00	14%	63%
More than 200.00	-	21%
Do not know	3%	3%

Table 7.2—Bairro Santo Antonio, Salinas

Price (Reais)	Fair Price	Could Afford to Pay
Up to 50.00	10%	10%
51.00 to 100.00	20%	15%
101.00 to 200.00	20%	25%
More than 200.00	5%	5%
Do not know	45%	45%

Table 7.3—Jatiboca

Price (Reais)	Fair Price	Could Afford to Pay
Up to 50.00	5%	5%
51.00 to 100.00	32%	16%
101.00 to 200.00	5%	21%
More than 200.00	-	-
Do not know	58%	58%

When asked how they would pay for the stove, 35% of families in Dom Orione said they would pay cash on the spot, and 65% said they would need some kind of financing. Of that 65%, 70% said they would use microcredit.

In Salinas, 80% said they would need financing, and of those families, 56% expressed that they would use microcredit. Twenty percent stated they would pay cash.

Fifteen percent of Jatiboca families said they would not be able to afford the stove, and 22% said they would like to buy but would not know how to pay for it. Some 26% said they would pay cash, and 37% said they would need financing. Of the 37%, 31% said they would use microcredit.

8.0 CleanCook stoves in Campground Setting

It was decided to place 5 CC stoves with the YMCA campground located in Serra do Cipo National Park, 100 km from Belo Horizonte, to determine if campers would be interested in using the stove. At the time of the study, it was the cold time of year when not many people frequent the park. During this time, most people go to the park for the day to hike, have some lunch and then return home. Also, the campground has a small restaurant and a snack bar where most people go for eating when visiting the campground.

Despite this causing less exposure of the CC stove to campers, for the 12 people that did use it while at the campground, 100% said it was a good stove for camping, better than an LPG stove. Because the park is at high altitude, it is quite cold during the night, and many users, 55%, stated that the stove was difficult to light. However, it was learned that the campground supplied a matchbook with shorter sticks for lighting the stove. Later, Project Gaia supplied longer matches to campers and, consequently, fewer complaints were recorded. Also, 44% of respondents did not like that the stove stained their pot bottoms. Still, a total of 67% of users expressed interest in buying a CC stove.

9.0 Discussion of Pilot Study from the Participants' Perspective

Considering the various aspects of introducing a new cooking technology into homes, the CleanCook stove and ethanol were well-received by study participants. Safety and ease of use can be attributed to the CC stove's success. Families were quick to understand operational safety of the stove, and many pointed out that because it cannot explode or leak fuel, they felt better knowing there was no danger to them and their children when the stove was being used.

Many of the families expressed concern about the environmental impact of collecting wood for cooking, and saw the stove as a possible solution to the challenge they face in seeking affordable cooking fuel. LPG is becoming too expensive to cook with for a rising number of families. In Salinas specifically, families now have to walk farther to find wood, which is leading to more people going out with carts and trucks to bring wood back to sell in the neighborhoods. Not wanting to walk, a greater number of families are now buying wood for cooking.

From an economic viewpoint, many of the families determined that the CC stove could be more affordable than LPG. They felt that given the CC's safety features and rapid cooking times, overall it was a better cooking stove than their LPG stove. Some pointed out that needing only 5-6 liters of ethanol a week would be less costly per month, if ethanol costs around R$ 1.00/ liter, than buying a 13kg LPG canister each month, which costs on average R$ 34.00.

The difference for some families is that they do not live on a fixed income, like the majority of people in Salinas. They prefer being able to buy cooking fuel in a small

amount as they have money available to buy it. It is very difficult for them to buy a 13 kg LPG canister in one bulk buy.

According to the National Petroleum Association (ANP), the average price of ethanol at the gas pumps is R$ 1.31 in Sao Paulo (January 2007). In Minas Gerais state, the average is R$ 1.80, and in Belo Horizonte, the state capital, it is R$ 1.74. In Salinas, the average is R$ 2.10 due mostly to transport costs. The price is lower in Sao Paulo because there are more gas stations and because many sugarcane plantations are located in that region.

For the families of the pilot study, this current reality of higher ethanol prices at the pump renders using the CC stove, if dependent on pump ethanol, as being more costly to use than LPG. Despite knowing this, many of the families of lower income or non-fixed income say they would prefer to cook with the CC stove, along with cooking with wood for some of their food items. They emphasize that many families in Brazil cook with more than one stove and that for them (those not living on a fixed income) the CC is a better option than LPG because it is clean, safe, fast cooking and because they can buy ethanol in small quantities.

10.0 Publicizing Project Gaia

Throughout the pilot study, several opportunities to present Project Gaia at various events were carried out. A summary of those events follows:

First Environmental Seminar of Betim, 1-3 June 2006. The event was promoted by the Municipal Government and had about 350 participants. The Project Gaia booth was very visible.

Local Renewable Energy Seminar, an ICLEI event, 27-29 June 2006. ICLEI—Local Governments for Sustainability is an international association of local governments and national and regional local government organizations that have made a commitment to sustainable development. The event attracted more than 250 people from Minas Gerais and other states around the country. Project Gaia was able to demo the CleanCook stove and distribute informational brochures and folder. Many visitors were interested in the project, including representatives of businesses that could make the stove in Brazil.

Fifth World Festival of Cachaça de Salinas, 14-16 July 2006. The municipal government of Salinas provided us a booth to display the stove and informational materials. It is a large event attended by thousands of people from Brazil and around the world. Many cachaça producers were interested in the stove, as was Minas Gerais Agency for Rural Technical Assistance.

17th Annual Peace Fair of Betim. The Municipal Secretary of the Environment provided Project Gaia with a booth in the area set up for renewable energy projects. Of the many visitors to the booth was the Department of Agriculture, who was interested in forming a partnership with PG.

Agricultural Expo of Mariana. Some interest in microdistilleries was mentioned by a few of the people that passed by our booth.

International Meeting about Indoor Air Pollution, Ecological stoves and Sustainable Development: This meeting was held in national capital of Brasilia on October 15-16th, 2006 and was organized by Project Gaia partner Winrock International. This meeting was attended by over 50 representatives from the federal government, universities, NGO, and private sector. At this meeting, Project Gaia International Director Mr. Harry Stokes and Regina Couto gave a presentation about the pilot project results in Brazil, and also had a booth for the parallel stove exposition. The meeting was very important for Project Gaia, not just to make public the project experience in Brazil, but also as new key contacts were developed with the house of representatives of Brazil, household energy researches, NGOs, and government authorities.

Project Gaia International Director Mr. Harry Stokes makes a presentation about Project Gaia pilot experience in Brazil during the meeting in Brasilia.

Field tour on IAP (Indoor Air Pollution): Following the meeting on IAP in Brasilia. Project Gaia International Director (Mr. Harry Stokes) accompanied a team consisting of Winrock International, Eco-Engenho (a local NGO), Shell Foundation, Aprovecho Research Center and Phillips on a trip to the interior of the Brazilian northeast (Alagoas state) to observe how rural people are exposed to IAP. This was a very interesting educational field visit, since Alagoas is one of the main ethanol producers in Brazil, while many in its rural areas are still exposed to IAP. Project Gaia donated to Eco-Engenho one CleanCook stove, so as to experiment and promote it as an alternative cook stove on the state of state Alagoas.

Mr. Harry Stokes observes a poor, rural woman in Alagoas State cooking and exposed to IAP.

17th National Artisans Fair, Belo Horizonte, 21-26 November 2006 Invited by its local partner Banco do Povo, Project Gaia participated in one of the largest events of this kind in Brazil, it lasts 6 days, and more than 170,000 people attended the event this year. Many people from different backgrounds were interested in the project: housewives, business owners, manufacturers, agricultural companies, and food vendors, who saw the CC stove as a perfect match for cooking some food items and as being safer to use in confined areas than LPG stoves.

11.0 Microdistilleries

An additional task for the project, Project Gaia team researched the existence and feasibility of small scale ethanol producers in the state. Initially, State Representative Deputy Padre Joao, author of the Law of Incentive for Microdistilleries in the State of Minas Gerais, informed the team about many EMD located in the state and suggested the PG team visit these EMD.

11. 1 Visits to Microdistilleries

The PG/Brazil Director, Regina Couto, and Winrock advisors, Rogerio Miranda and Andre Oliver, visited each of these producers, and also visited and talked with various scholars and experts in the field about this technology. The following is a recap of those visits:

Mateus Leme (70 km from Belon Horizontes), Producer – Marcelo Guimarães. Dr. Marcelo is an engineer with vast experience working on energy issues in the public sector. He recommended equipment for producing ethanol for personal use. He makes enough ethanol to fuel 7 cars for family members, and has a partnership with cachaça producers who give him the cachaça waste product which he then uses to make ethanol, of which he returns to them and they pay him in bottles of cachaça for his services. He proposes that alcohol production could be increased if produced from cattle waste

(biogas). He has eucalyptus planted on his property that is used to fire the microdistillery. Marcelo says that 1 hectare planted with sugarcane would yield 100 tons of cane and produce up to 10,000 liters of ethanol. In his case, 100 tons of sugarcane produces 7000 liters of ethanol.

A micro distillery that produces cachaça and ethanol at Viçosa University. Viçosa is a Brazilian city in the state of Minas Gerais, located in the Zona da Mata, 275 km southwest of the state capital Belo Horizonte. Professor Juarez da Souza is very interested in Project Gaia, and has agreed to explore a possible partnership between the university and Project Gaia to carry out an additional study on the concept of local cooperatives producing ethanol for household energy use.

11.2 Creation of Microdistilleries

Microdistilleries have a possible application in rural Brazil to alleviate poverty, especially in agricultural families. The national legislature has recognized this; three laws are currently being debated in the legislature regarding providing market incentives for EMD. In Minas Gerais there is a state law that provides incentive to microdistilleries, though it is not yet fully implemented.

The increasing global demand for ethanol as an automotive fuel and for sugar has proven very beneficial to the large sugar companies, as internal market prices have increased with global demand. Microdistilleries could be used to supply the local markets and perhaps keep costs down domestically in some key regions.

A microdistillery that produces 100 to 500 liters per day could be managed by one farming family. Aside from producing ethanol for their own use, they could also produce other products: rapadura, sugar, and cachaça. The social impact could lead to a better quality of life in rural areas through the generation of increased family income, which may prevent more rural people leaving their farms and the countryside for the cities in hope of finding a better income and a better quality of life.

Environmental impact from waste products from sugar plantations are reduced by using the residual sugarcane bagasse to feed cattle after they are first used to produce ethanol. Another residue from EMD, the "vinhoto" can and should be used as fertilizer in the fields. Using EMD residues at the farm level is a perfect fit for this technology. For local governments, by improving the quality of life in rural areas through the promotion of micro-distilleries, costs for social programs would decrease.

Under the lens of sustainable development, the production and utilization of renewable energy guarantees a healthy future for generations to come. Also, the potential for carbon credits being applied to microdistilleries could help Brazil reach some of the Millennium Development Goals, most notably goal #7: Guarantee a Sustainable Environment.

12.0 Outlook

Extending the initial pilot study to further investigate the notion of microdistilleries should be considered as a necessary next step for Project Gaia/Brazil. Pump ethanol is high in price. Microdistilleries would possibly be the answer to supplying affordable cooking fuel to families, and could be used to generate income from other activities, e.g. cachaça.

Two ethanol producers in Mateus Leme and Ponte Nova stated that ethanol produced by microdistilleries has a production cost of about R$ 0.70. The Federal University of Vicosa confirmed this price.

A mini-pilot with a community that has equipment to produce ethanol would involve providing a CC stove to those members that participate in the cultivation of sugarcane and production of ethanol. Several possibilities are on the horizon; the PG team will explore them.

Dom Orione is one potential site. Having received equipment to make rapadura (sugar candy) from the municipality, they are very interested in gaining the other technology needed to produce ethanol. Some 84% of the families in Dom Orione participated in the PG pilot study. It would provide a focal point and visibility for the project, be of importance to the municipality, and could be a case study to be featured with ICLEI. The Municipal Secretary of the Environment and the Municipal Secretary of Economic Development is evaluating the possibility of establishing a partnership with the project where the community would also provide ethanol for the municipality's fleet of flex fuel cars.

The municipality of Mariana also has microdistillery technology. The mayor of the town is president of the Association of Minas Gerais Municipalities. He is interested in the project, and given his professional status, would provide great visibility to the project.

In Salinas and Aracuai, both in the Jequitinhonha Valley, it may be possible to partner with cachaça producers. A municipality owned distillery could be used to produce ethanol from cachaça waste products. The cachaça producers would get ethanol returned to them and the municipality would provide ethanol to homes that participate in the study.

In Vicosa, a former director of the household economics faculty of the Vicosa Federal University is willing to explore the possibility to convert her former cachaça farm into an EMD, in order to supply a small town nearby with ethanol for cook stoves.

Beyond Minas Gerais, and Brazil even, the potential replication of the microdistillery concept is far-reaching. In tropical regions around the world where sugarcane and other crops are grown, and where cooking fuel options are often little more than scarce wood and charcoal supplies, dangerous kerosene, dung and agricultural residues, microdistilleries are a potential energy source for millions of people.

13.0 Conclusions

The pilot test of the ethanol-fueled Clean Cook has produced positive results. The stove was well accepted by the families in terms of safety, easiness to use, appearance, cleanliness and fuel consumption. The negative aspects mentioned are related to the convenience of cooking, e.g. a better platform to hold the pots, more cooking eyes, and additional feet, but are all easily remedied with simple technical solutions on the stove design. The fuel consumption of the stove was relatively low, requiring most refueling to occur between 2 to 3 days. This is due to the small size of the fuel canister. Even the request of some households to add an oven is a possibility considering that Dometic already has a commercial model with an oven, but of course at a higher price. One limitation of the Clean Cook to replace wood stoves is that it does not have a coil to heat water, but it is the same limitation that the popular LPG stoves have.

The price of the stove could be substantially reduced if manufactured in Brazil, even though the surveyed households have demonstrated a willingness to pay the anticipated real market price for it. Brazil has a strong metals industry which could manufacture stove bodies that are less costly than the stainless steel stove model used in the pilot study.

It seems clear that the Clean Cook stove displaces a greater quantity of the LPG stoves than the wood stoves. The obvious reason for this is fuel cost. The attractiveness of using the Clean Cook stove is characterized by being able to buy the fuel in small amounts, and in its faster cooking time over the LPG stoves. The field trial indicates that the Clean Cook can be an alternative to LPG stoves, has a higher usage time than LPG, which then displaces the wood stoves usage time, and thus has the benefit of reducing exposure to

indoor air pollution, especially among the majority of families that have a combined usage of LPG and wood stoves.

One challenge for the Clean Cook identified in this field trial was the availability of lower cost ethanol supply. Unfortunately, in the two communities of Dom Orione and Santo Antonio the much expected fuel supply from ethanol microdistillery (EMD) did not happen. According to a Brazilian specialist on EMD, it is quite possible to have EMD producing ethanol at a cost of R$ 0.60 to 0.70 per liter, which could then be resold at R$ 1.00 to 1.20 per liter locally, which is within the willingness to pay provided by the surveyed households, and at much lower cost than the ethanol available at the fuel stations.

Although EMD are not permitted to sell their ethanol commercially in the open market, it is quite feasible set it up as a cooperative or association between households and the EMD. Nevertheless, EMD is a technological option that goes beyond Brazilian borders. Considering the actual scenario of increasing LPG prices worldwide, and given a foreseeable heavy carbon dioxide tax in fossil fuels associated with global warming, biofuels and, notably, ethanol are the most obvious alternative to LPG in the coming future where some 2.4 billion people will not have access to cleaner cooking fuels.