Babington Technology Field Test for Pugnido Refugee Camp School Feeding Program
Gambella, Ethiopia

Results Report
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1. Background

Securing a clean energy supply to meet the cooking demands of households and institutions in Ethiopia continues to be a major challenge. The refugee camps in Ethiopia are also facing similar challenge to meet refugees' energy need. To address this, the United Nations High Commissioner for Refugees (UNHCR) country office endorsed a national energy plan in early 2015 to solve the energy crisis in the refugee camps by introducing clean cooking and lighting technologies. As part of this wide effort, Project Gaia established a consortium of partners that includes Gaia Association, Babington Technology, Horn of Africa Regional Environment Center & Network (HoAREC-N), UNHCR and the Ethiopian Government's Administration for Refugees and Returnees Affair (ARRA) to introduce a revolutionary new technology designed to mainly meet institutional cooking needs (e.g., for hospitals, schools, canteens, etc.). The new technology will eventually be adapted to meet household cooking needs in the refugee camps and beyond.

The partners planned to introduce and test the Babington technology at Pugnido refugee camp in Gambella Region of Ethiopia. The technology is capable of burning any liquid fuel (e.g., distillate fuels such as kerosene and diesel, ethanol bio-fuels from plant oils, even waste oils.) cleanly and efficiently without smoke, black carbon or carbon monoxide. The introduction of this clean burning and affordable technology into refugee camps and beyond in Ethiopia will create opportunities for more sustainable energy use and practices that will have a dramatic positive impact on institutional cooking related problems in refugee camps.

Prior to the introduction of Babington technology at the camp, the partners conducted a baseline study of the Pugnido camp's School Feeding Program in April 2015. Between November 06 and November 20 of 2015 the Babington technology underwent pilot testing at Pugnido camp for two weeks. The test was conducted by introducing four different types of Babington cooking appliances that are fitted with the same Airtronic burner. The pilot test identified the appropriate appliances and the necessary minor-modifications to meet the specific cooking demands of the School Feeding Program. Following the pilot, additional appliances of selected types will be introduced to Pugnido camp school kitchens. This report presents the results of the baseline and pilot studies conducted on Babington technology at Pugnido camp school kitchens.

2. Pugnido Refugee Camp

UNHCR operation in Ethiopia hosts more than 630,000 refugees from troubled neighboring countries in 23 camps. Pugnido camp is one of the five camps UNHCR has in Western Ethiopia to host more than 300,000 South-Sudanese refugees. The camp is located 900Km from Addis Ababa city and 110Km from Gambella town (major town of the region). Pugnido camp was established in 1986 and is one of the first refugee camps in Ethiopia. At present, the total refugee population in Pugnido camp is estimated to be about 62,836. Over the years, UNHCR and its implementing partner organizations have developed camp infrastructure that includes but is not limited to administrative quarters, schools, clinics, social service centers, market areas, and distribution centers.

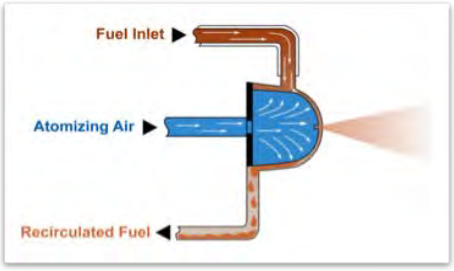
UNHCR Refugee Camps in Ethiopia (Source: UNHCR, 2015)

As in the other refugee camps of Ethiopia, firewood is widely used in Pugnido camp for both household and institutional cooking. Institutional cooking in the refugee camps is mostly done at schools, hospitals and in cafeterias of agencies running refugee programs. The cooking at the camp's schools is part of the World Food Program (WFP) global initiative to provide meals to school children. At present, Pugnido camp is the only camp with school feeding program in Gambella area refugee camps since the others are recently reopened following refugees influx from troubled South Sudan. Pugnido camp has four separate kitchens at each school that are running school feeding program to serve meals to 10,303 students. All the school kitchens are using semi-improved firewood stoves to cook Corn-Soya Blend (CSB) meals for the students at the four schools of the camp.

However, firewood use for cooking in UNHCR refugee camps is causing health problems and immense deforestation and environmental degradation, not to mention the tension it is creating between refugees and host communities. Previous efforts by UNHCR and partners to reduce firewood reliance for cooking in some of the refugee camps of the country have shown significant improvement in the lives of refugees by lessening exposure to indoor air pollution, time spent for cooking and firewood gathering, and conflict with host communities. Moreover, significant results are achieved in relation to increased children school attendance and reduced deforestation and land degradation as shown by various studies conducted.

3. The New Institutional Cooking Technology

The new institutional cooking technology pilot tested at Pugnido camp is designed and manufactured by Babington Technology, which is based in the US. The heat source of the cookstove is a unique oil burner technology that can burn any liquid fuel to near perfectly clean combustion at low heat outputs. In contrast to conventional burners, the Babington technology can atomize a liquid fuel to such a fine particle mist that it burns completely, much like a gas, producing no smoke, odor or carbon monoxide. This enables a wide range of high-efficiency, multi-fuel and portable heating and cooking applications for institutional use. Based on an entirely new engineering principle, the Babington technology developed a unique low-pressure, air atomization method, which sprays liquid fuel particles so fine they contain 1,000 times less fuel than droplets produced by conventional spray nozzles.



Patented Babington
Principle of Atomization

Makes Ultra-
Fine Spray
(Sub-micron – 10 microns)

Burns Any Liquid
Fuel Like a Gas

The atomized liquid fuel in this manner will ignite instantaneously and burn cleanly like a gas. The advanced vaporization effect leads to smokeless performance and near perfect (stoichiometric) combustion at variable low heat outputs, which are infinitely adjustable between 450 to 105,000 BTUs/hr. The clean burning technology can be delivered on any scale and in the form of low powered, energy efficient cookstoves and appliances, meeting individual, household or commercial needs. At the heart of every Babington appliance is the Babington-Airtronic burner, which burns the atomized fuel cleanly. The Babington-Airtronic burner works in the atomization principle and is capable of burning multi-liquid fuels including biofuels, plant oils or fossil fuels. When there is an insufficient biofuel supply, diesel, kerosene, ethanol or a blend can be used to meet institutional cooking needs.

Babington-Airtronic Burner

The partners selected four different types of Babington institutional cooking appliances for the pilot test at Pugnido refugee camp. All of the appliances are fitted with the same Airtronic burner and automatic controls that simplify the operation of the appliances by users. Each appliance requires up to 140Watts of electric power to run the fuel pump and air compressor inside the Airtronic burner as well as to power the automated control box. The following types of Babington appliances were selected and pilot tested at the camp:

- **Tray Ration Heater (TRH):** It is a double-walled cooker with a 60lit cooking pot inside. It has an excellent thermal transfer and outside insulation that keeps the water jacket and food cooked at a high temperature for a desired time period.

Tray Ration Heater (TRH)

- **Corn-Soya Blend Cooker (CSB Cooker):** It is a double-walled cooker specially designed for CSB cooking at refugee camps. The CSB Cooker can cook up to 250lit at a time.

Corn-Soya Blend Cooker (CSB Cooker)

- **Multi-Function Cooker (MFC):** It is a simplified design engineered to meet the multiple cooking needs of different institutions using large pots on the firebox of the stove. The small holes in the top of the firebox serve as an effective means of spreading the heat uniformly as the hot exhaust gases leave the firebox of the heating sled.

Multi-Function Cooker (MFC)

- **Powered Multi-Function Burner (PMB):** It is a more simplified design of the MFC created to meet the multiple cooking needs of different institutions using large pots on top of the firebox of the stove. Similarly to the MFC, the small holes in the top of the firebox serve as an effective means of spreading the heat uniformly as the hot exhaust gases leave the firebox of the heating sled.

Powered Multi-Function Burner (PMB)

4. Test Methodology

4.1 Camp School Feeding Background

The camp's schools run two cooking sessions each day, one in the morning and another in the afternoon. The CSB meals are served to schoolchildren at their breaks, 10:00am in the morning 4:00pm in the afternoon. The school kitchens use similar semi-improved firewood stoves. Each kitchen uses 7 or 7 semi-improved firewood stoves. The schools are open five days of the week and ten months of the year. A tractor load of firewood is supplied by ARRA every week and wood-choppers at the school kitchens prepare and provide wood pieces to the cooks.

Pugnido Camp School Kitchen & Wood Chooping at School Kitchen

CSB is the only food cooked for schoolchildren at the camp schools. The CSB is prepared using 120lit volume pots in all of the kitchens. The CSB is cooked by first boiling 60lit of water followed by mixing 15Kg of CSB and 3Kg of sugar in 40lit cold water solution. The CSB and sugar used is measured by the Center Cooking Supervisors while the water is measured by cooks during every cooking session. The CSB and sugar solution is poured and mixed with the boiling water and continuously stirred until the CSB is ready. The boiling water and CSB-Sugar mix is cooked for an average 30min before it is ready for consumption.

CSB Cooking Ingredients Measurement

The study team, comprised of Gaia, HoAREC-N and ARRA, sought to study the stoves and conduct evaluation. Furthermore, the Babington technology pilot study was visited by Camp and Zonal Officers of UNHCR and ARRA.

New Cooking Technology Visitors from ARRA and UNHCR

Operation and maintenance training is provided to the staff of ARRA to facilitate further experiments and trials by ARRA:

Operation and Maintenance Training to ARRA Staff

4.2 Technology Installation

4.2.1 Burner testing: all the burners in the stoves were dismantled, tested and serviced prior to the test.

Burners Troubleshooting

4.2.2 Installation: the stoves were placed at suitable places for operation and avoiding interference with the usual cooking process.

Stoves Installed in School Kitchen

4.2.3 Test run & training of cooks on how to use the stove: the burners were fitted back to the cookers and test run was done. Water was heated using the cookers for the test run and the comment from the cooks on the temperature (readiness for cooking) was taken as a reference for the test. After the water heating test, the cookers were used for actual food preparation. The prepared food was tested by students for comment. Training has been given for all the cooks in

the kitchen starting from the test and throughout the testing process to all the cooks in all shifts on how to use the stove. They were able to open, close, tell when it is ready etc.

Stoves & Cooking Trials

4.2.4 Cooking trial: the CBS cooker was able to replace two of the 150 litter pots which were used in the fuel wood stoves. The TRH cooker was only able to cook 60 litters of food. The 150 litter pot was used on the MFC cooker but the PMP cooker was not able to accommodate any of the pots used in the kitchen. The fore, a pot rest modification has been designed and manufactured. Data was collected while the cooking is done. Cooking starts at 7:00 in the morning. All the stoves are used to prepare food to be ready at 10:00 for students. Information like amount of water added, starting time, time for water boiling, temperature, amount of fuel, time of cooking is recorded.

Cooking Trials & Experiment

4.3 Baseline Methodology

- The Controlled Cooking Test (CCT) protocol from the Global Alliance for Clean Cookstoves is applied. Two kitchens were selected for the CCT, considering all the camp school kitchen are similar in terms of the type and amount of food cooked as well as similar in pots, stoves and fuel they use. The firewood prepared and provided to the cooks is measured along with its moisture content.

4.4 Pilot Test Methodology

- The Controlled Cooking Test (CCT) protocol from the Global Alliance for Clean Cookstoves was applied. As in the baseline study, the pilot test was conducted in two kitchens. Stove use training was provided and sufficient time was allowed for the cooks to become familiar with the stoves. Similar amounts or a proportional quantity of CSB and water was measured and cooked with the new stove. Fuel consumption

measurements and cooking times were registered. Data was also collected by the following methods:

- Survey questionnaire to 7 cooks,
- Focus group discussion (FGD) with 11 cooks, and
- Observations.

5. Results

5.1 Results of Baseline Study

Table 1: Baseline Firewood Cooking Test Result

Test Site	Number of Students	Number of Test Rounds	Number of Test Stoves	Average Result of Measured Parameters					
				Weight of CSB cooked (in Kg)	Weight Sugar mixed (in Kg)	Volume of Water used for cooking (in lit)	Cooking Time (in min)	Weight of firewood used (in Kg)	Firewood moisture content (%)
Site-1	2894	**5**	**5**	**15**	**3**	**100**	**78**	**14.9**	**17.4**
Site-2	2524	**4**	**5**	**15**	**3**	**100**	**75**	**14.6**	**17.1**

On average, each stove consumes 14.8Kg of firewood and takes 76.5min to cook CSB. The results show that 740Kg of firewood is consumed each day by the four kitchens and 25 stoves that cook in two shifts. This is estimated to be 163ton of firewood consumption annually for 10 months the schools are open each year.

School Kitchens' Semi-Improved Firewood Stoves

5.2 Results of Pilot Study

5.2.1 CCT Result

Table 2: Pilot Test Cooking Result

Test Site	Type of Appliance	Number of Test Rounds	Average Result of Measured Parameters				
			Weight CSB cooked (in Kg)	Weight Sugar mixed (in Kg)	Volume of Water used for cooking (in lit)	Cooking Time (in min)	Fuel/Diesel Consumption (in lit/hr)
Site 1 & Site 2 (5,418 students)	**CSB Cooker**	**8**	**30**	**6**	**200**	**150.5**	**1.44**
	TRH	**6**	**10**	**2**	**65**	**91.5**	**1.38**
	MFC	**9**	**15**	**3**	**100**	**81**	**1.41**
	PMB	**4**	**15**	**3**	**100**	**78**	**1.38**

The Babington stoves have an average fuel consumption of **1.4lit per hour** while it takes an average **78min** to prepare a 120lit pot size CSB.

Cooks Using Babington Stoves and ARRA Staff Supervising

5.2.2 Result of Survey Questionnaire and FGD

The school kitchen cooks stated that they are facing daily problems because of the semi-improved firewood stoves they are using. The cooks explained they suffer from skin burns, low-blood pressure, less sleep, eye problems and even perceive the stoves to have a negative effect on their reproductive health. Moreover, cooking with large pots and firewood is challenging. In addition, the pots are burned, which makes cleaning very difficult and time consuming.

Firewood Stove Burned Pots

The cooks stated they are happy with the new technology introduced and the cooking experience because the stoves:

burn cleanly

do not have a burning flame

are easy to wash since they do not burn the food

do not require their attention all the time and easy to cook with

Both the survey and FGD show similar results regarding appliance preference ranking:
The CSB-Cooker is ranked 1st, MFC 2nd, PMB 3rd and TRH 4th.

FDG and Survey

The women stated that they are generally happy with all the different types of Babington appliances and that the differing sizes of the stoves influenced their rankings. The CSB-Cooker was favored because it can reduce the need for two large pots cooking to one. They reported that,

unlike the firewood stove, which requires a cook's attention for each large pot, a single cook using the CSB-Cooker can cook two large-pot's worth of CSB. The TRH is preferred least because of its smaller size. The cooks found using the new technology to be easy, but pointed out that more training is necessary. They believed that switching to the new cooking technology will improve their health and make their jobs easier because it is clean and it does not require constant attention. They pointed out that they could attend to other duties and activities since the new technology requires minimal attention.

School Kitchen Cooks

6. Summary and Recommendations

The study team observed that cooking for the school feeding program with firewood is a difficult task that exposes the women cooking to high levels of carbon monoxide and particulate matter. Though the cooking time for the firewood stove is reasonable, lighting the firewood stoves and cleaning burned pots is time consuming. Cooking with the firewood stoves requires the full attention of the cooks to ensure that the fire is burning as well and to continuously stir the pots in order to minimize CSB burning at the bottom of the pots. Furthermore, dependency on firewood for cooking consumes a significant portion of ARRA's financial and logistical resources due to the need to identify sources for firewood and to collect and supply the kitchens with firewood.

The Babington technology has proven to be ideal for cooking CSB for the schoolchildren and is preferential to firewood stoves. The cooks have found the new stoves to be easy to cook with and clean. They have observed that the stoves do not burn the CSB and do not require their constant attention, freeing up time for meal preparation activities. The clean burning stoves and the new possibility to prepare a larger volume of meals in the same amount of time were highly valued by

all of the cooks. The CSB-Cooker was the appliance favored by all of the cooks as well as by the supporting staff of the school feeding program. The study team also strongly believes it is the ideal type of appliance that can replace two firewood stoves with a single CSB-cooker. The MFC and PMB were also found to be well-liked and suitable stoves for the schools CSB cooking, even as a one to one replacement. The new technology replacement strategy should consider the cost advantages between the stove choices when deciding between CSB-Cooker versus MFC/PMB.

Though there was no major challenge faced during the pilot trial, the study team strongly believes the following technical issues should be addressed on the next round of selected appliance-types before introduction into the camp:

- Despite the minimal electrical power requirement of the stoves, a self-independent power system introduction is vital to successfully replace firewood stoves with Babington technology. The pilot was conducted using an electrical generator, exposing a challenge for the cooks to run the stoves smoothly, in addition to the extra fuel and maintenance requirement. Supplying the electrical power required by the Babington stoves using a solar-powered system will make the stoves operation easy, as well as energy efficient.
- The Babington technology is fitted with different sensors and programmed automated control, making it safe and easy to use. However, the team observed that it can be challenging for the camp cooks to understand some of the automatic reactions and shutdowns of the system. As a result, it is highly recommended to make most of the system manual in order to facilitate easy operation by the cooks.
- The MFC and PMB pot seats needs to be modified to accommodate the 120lit pots of the camp kitchens so that better energy efficiency can be achieved than that which was observed during the pilot test.
- Fuel purchased and used in the camp area is observed to have higher impurities than usual, requiring a highly withstanding fuel filter for the Airtronic burners of the appliances.

The study team suggests the following changes for successful intervention of Babington Technology in refugee camps and beyond:

- Integrating Solar PV system as an electric power source for the burners. Solar power is preferred off-grid source in Ethiopia.

- Less automated operation system. For example, replacing most controls into manual controls.
- Pot-rest modification to be able to accommodate pots with 60 cm diameter bottom. And also to be used if necessary, the pot-rest should be able to accommodate pots with diameter as small as 30 cm.
- Modify the burner fuel flow system to be less sensitive for impurities in the fuel. Or fitting fuel filter that can withstand fuel impurities.
- Conducting further tests on the burners using plant-oil, used cooking oil and used motor oil to go in-line with the Ethiopian government effort to promote use of Plant oil and utilize waste to Energy.

The introduction of this clean technology will successfully replace the use of firewood, thereby reducing the health hazards to the cooks due dirty cooking fuel while simultaneously making the jobs of cooks and other staff easier. It will also reduce negative environmental impacts stemming from firewood collection and consumption and reduce the associated cost burdens shouldered by ARRA and UNHCR.