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IMPROVED COOKING TECHNOLOGY PROGRAM

(RECHO PAW)

LONGITUDINAL STUDY OF EIGHT IMPROVED COOKSTOVES IN PORT-AU-PRINCE

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ACRONYMS USED IN THE DOCUMENT

ICS:	Improved Cook Stove
KPT:	Kitchen Performance Test
IAP:	Indoor Air Pollution
LPG:	Liquified Petroleum Gas
SUMS:	Stove Use Measurement Systems
CO:	Carbon Monoxide
PM:	Particulate Matter

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We would like to thank all the people who opened their kitchens to us and patiently answered our questions. A big thanks too to the surveyors of AMURT for their hard work. Last but not least, thank you to the staff of the Improved Cooking Technology Program (RECHO PAW) for their vision and pragmatism in overcoming the hurdles that inevitably come with such a long and extensive field study.

ABOUT THE IMPROVED COOKING TECHNOLOGY PROGRAM (RECHO PAW)

This USAID-funded project aims to reduce pressure on Haiti's forests, encourage local and sustainable solutions to environmental concerns, and create cooking options for Haiti that are clean, efficient, affordable, and able to meet local cooking needs. The project focuses on households and large charcoal consumers in Port-au-Prince, expands the market for improved biomass cook stoves and cleaner fuels, assists clean fuel and cook stove suppliers, and addresses regulatory issues that are limiting the expansion of liquefied petroleum gas in the household market. The project also leverages emission reductions resulting from clean cook stove use to generate scale-up revenue through international carbon markets.

ABOUT THE AUTHOR

Olivier Lefebvre is a monitoring and evaluation consultant with a focus on the clean energy sector. He has designed, implemented and analyzed the results of about a dozen studies on three continents. In 2013 he founded Climate Solutions Consulting.

Climate Solutions Consulting is a US-based company providing quality impact evaluation and monitoring services in the field of energy access. More at: www.climate-solutions.net

DISCLAIMER

The author's views expressed in this publication do not necessarily reflect the views of the United States Agency for International Development or the United States Government.

I. SCOPE AND LIMIT OF THE STUDY

This longitudinal study of eight improved cookstoves in the Port-au-Prince area has a very comprehensive scope. It is a longitudinal performance assessment of available models of improved Cookstoves (ICS) in typical charcoal using Haitian households to better understand the potential improved household cookstove market in Haiti. The primary objectives of the study are to understand consumer preferences on the one hand, and on the other, to explore key stove design issues that reduce efficiency and durability with daily use.

Very few longitudinal studies have been implemented, documented and released to either the public and/or stove manufacturers. As a result, many existing stove models, though believed to have certain features or lifespans, in fact fail to meet consumer expectations in some areas. This study seeks to provide credible feedback on consumer preferences after adequate exposure to their products. This and other important information are captured in the study and presented to stove producers who intend to supply these stoves to the Haitian market, especially as the benefit of carbon finance becomes available to support deeper market penetration at discounted prices.

To draw a global picture of how the improved stoves functioned during a one year period the study looks at the following aspects:

- **Adoption:** How are the improved stoves being used by the households? For what purposes? How well adapted are they to the local cooking habits? How are they used in combination with the other stoves owned by the households?
- **Stove design:** How easy are they to use? Are they seen as modern? Are they the right size? What improvements do users recommend?
- **Fuel savings**: How much do the stoves reduce fuel consumption? Do they reduce cooking time?
- **Damage and maintenance:** How did the overall conditions of the stove evolve during the study? What parts of the stoves have been damaged? What maintenance operations were done by the households?
- **Health and safety impact:** What are the frequency and reasons of burn injuries? What are the users' perceptions of the health impacts associated with the stoves' emissions?
- **Perceived value:** What is the estimated price of the stove? How willing are the households to consider financing as a way to purchase the stove?

The choice to include 8 different stoves meant a smaller sample size for each stove, but this tradeoff is balanced by the perspective brought to the results by including eight different improved cookstoves. The performance of each stove can indeed be compared to the results of the other stoves.

For logistical reasons, the households interviewed were chosen by the NGO AMURT (who administered the survey) in the neighborhoods where they already work. For a one year study with

so many surveys it was indeed key to secure the full cooperation of the households. It would have been quite difficult to secure the cooperation necessary with households who had no relationship with the interviewers. The aim of the study is not to give a representative image of the cooking practices of Port-au-Prince as a whole but rather to study how the introduction of improved stove in typical households change their practices.

Baseline data for Port-au-Prince can be found in the publicly available National Baseline Study conducted earlier by Papyrus consulting for the USAID ICTP/Recho Paw Program or the Port-au-Prince baseline assessment report published by Entrepreneurs du Monde - PALMIS Enèji with Initiative Développement (to be published in 2015).

II. METHODOLOGY

a. Sample design

The overall sample size is 120 households; each type of stove was placed in 15 households. A two-stage sampling approach was adopted. First, five neighborhoods were chosen within the greater Port-au-Prince area and then 20 to 30 households were selected in each of those neighborhoods. The improved stoves were distributed homogeneously in each area.

Figure 1: map of the selected area

The five areas selected for this study are Delmas 31, Bourdon, La Plaine, Peguyville and Barocia. The map below shows their location. The locations were chosen to offer a wide spectrum of living conditions ranging from downtown Port-au-Prince to suburban areas on the northern plains and on the southern hills. All locations were areas where AMURT has established a presence.

The households were then selected randomly among the ones that were willing to participate and that were using charcoal on a regular basis (since all of the improved stoves tested are charcoal stoves). The participants were promised their choice of a new locally manufactured stove at the end of the study.

The stoves were distributed as follows in the different areas:

Area	Burn	Envirofit	EcoZoom Prototype	Eko Recho	GIZ Benin Éclair	Haiti Men Recho	ILF-Plop Plop Stove	Prakti Stove	Total
Barocia	3	2	3	4	2	2	1	3	20
Bourdon 1	3	4	4	3	4	4	5	3	30
Delmas 31	2	3	2	2	3	3	3	2	20
Laplaine 1	4	4	3	4	3	4	4	4	30
Pegyvil	3	2	3	2	3	2	2	3	20
Total	15	15	15	15	15	15	15	15	120

Table 1: overview of the stove introduction in each area

b. Schedule of the study

The longitudinal study compares the results of surveys done before the introduction of the Improved Cook Stoves (ICS), called baseline, to surveys done at various times after the introduction of ICS (monitoring). Three monitoring surveys were done at 3 months, 9 months and 12 months respectively after the introduction of the stoves.

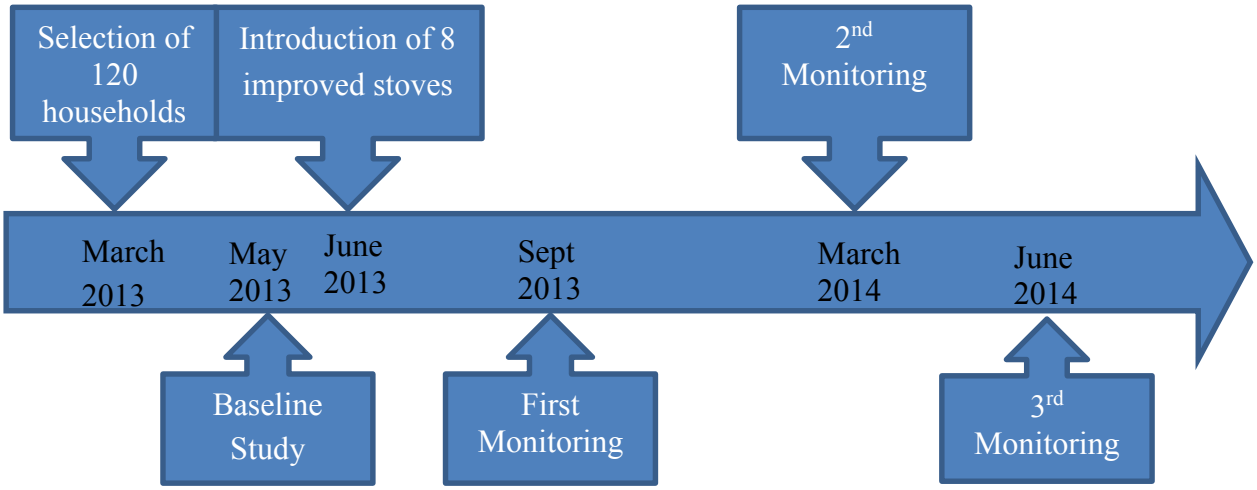


Figure 2: Schedule of the study

In addition to those three monitoring surveys, data from Stove Use Measurement Systems "SUMS" was downloaded every two months between June 2013 and June 2014.

c. Types of data collection tools used

Information was gathered through a series of qualitative and quantitative data collection methods including scientific test methods, qualitative surveys and quantitative measuring systems. The four tools used are as follows:

i. Qualitative Survey

This survey collected most of the information needed for the study. It focused on the type of stove, the fuel used by the households and their cooking patterns. It also explored households' habits regarding stove cleaning and maintenance and their perceptions of stove safety, health impacts and value.

ii. Kitchen Performance Test (KPT)

The kitchen performance test is an uncontrolled, household level test. It assessed real world consumption of fuel by the households during 72h (3 full days in a row). Charcoal, firewood, kerosene and LPG consumption were assessed depending on the types of fuel used by the household. The tests were conducted with a scale calibrated before each round.

iii. Indoor Air Pollution (IAP) Survey

This survey assessed the IAP associated with the use of the stoves at baseline and then after with the Improved Cook Stoves. The level of Particulate Matter smaller than 2.5 micron (PM 2.5) and the level of carbon monoxide (CO) were measured. Four IAP meters developed by the Aprovecho Research Center were used in this study. The level of CO and PM were monitored continuously over the course of 24 hours. The IAP meter was placed 1.3 m meters above the stove.

iv. Stove Use Measurement System (SUMS)

The SUMS are tiny devices that were placed on the stove surface to monitor its temperature. They take one measurement every 10 minutes. One SUMS was placed on each improved stove and monitored the temperature during the whole year of the study. This allowed tracking of precisely when and for how long the stoves were used.

d. Stoves included in the study

Four locally available stoves and four imported stoves for a total of eight stove models were identified to be part of the study. These eight stoves are described in more details below. Dimensions for the stoves represent length, diameter/width and height.

EcoRecho: • designed and produced by D&E Enterprises, • manufactured in Haiti • dimensions: 30*30*20 cm • local retail price: starting at 450 HTG (10 US$)	
CH – 5200: • designed and produced by Envirofit International • manufactured in China • dimensions: 16.2*35.0*30.0 cm • local retail price: N/A as this stove is not available on the Haitian market yet	
PlopPlop: • designed by International Lifeline Fund (ILF) • manufactured in Haiti by D&E Green Enterprises • dimensions: 27*.5*27.5*21 cm • local retail price: starting at 550 HTG (12 US$)	
Prakti Wouj: • designed and produced by Prakti Design, • parts are manufactured in India and stove is assembled in Haiti • dimensions: 23*23*17.5 cm • local retail price: starting at 1,975 HTG (43 US$)	
Men Recho: • designed and produced by Haiti Metal • manufactured in Haiti • dimensions: 33*33*29cm (without the skirt) • local retail price: starting at 650 HTG (14 US$)	

Jikokoa (older model, named Charbel in Haiti): • designed and produced by Burn Design Lab, • manufactured in Kenya • dimensions: 25*25*19.5 cm • local retail price: N/A as this stove is not available on the Haitian market yet	
Éclair prototype: • designed and produced by GIZ, • manufactured in Benin • dimensions: 35*35*29 cm (without the skirt) • local retail price: N/A as this stove is not available on the Haitian market yet	
EcoZoom Prototype: • designed and produced by EcoZoom, • manufactured in China • dimensions: 28*28*26 cm • local retail price: N/A as this stove is not available on the Haitian market yet	

Please note that the locally produced stoves often come in two sizes to fit the most popular sizes of pots for domestic use. The dimensions provided here and used in the study are for the smaller size of stove which fits the medium-sized local pots and pans used by most families.

e. Presentation of Results

Between the baseline and the three monitoring surveys, the SUMS, IAP meters and KPT, more than ten thousand different variables were computed for this report. We have tried to organize the data in a coherent way and attempted to create a synthesis that will not overwhelm the reader.

Whenever there was some evolution of the data between the first, second and third monitoring with a clear trend the data is presented as such. However, to increase the readability, when no meaningful change was noticed between surveys the average for the three monitoring periods is shown here.

For the same purpose, when the data is such that one chart is needed for each stove, then a chart showing the average of all the stoves is presented in the main part of the document while the detailed results for each stove will be found in annexes.

III. RESULTS

a. Adoption

v. Context: a multitude of stoves and fuels

Figure 4: iron bars traditional charcoal stove (Recho Zo Reken)

Figure 3: round sheet metal traditional charcoal stove (Recho twa pye)

Charcoal is the main source of cooking fuel in Port-au-Prince with stoves being made either out of cheap sheet metal (often recycled) which has a short life span, or a more expensive stove being made with iron bars that will last longer and can cook up to three pots at the same time.

Kerosene and LPG are also used in the capital city although much more rarely than charcoal.

Figure 5: kerosene stove

Figure 7: LPG stove

Figure 6: 3-stone fireplace

Firewood is also sometimes used in the suburban areas of Port-au-Prince where people can collect it themselves. Since it is bulkier and more complicated to transport, it is not used in Port-au-Prince.

vi. Main/auxiliary stoves

The study show that before the introduction of the improved cookstoves households used a wide variety of stoves to meet their cooking needs. About 50% of the households used two different

stoves for cooking, with one stove being used more often than the other. Most households, and especially those who owned only one stove, used stoves with two or three burners to allow them to cook many items at the same time.

Right after the improved cookstoves were introduced, they became the households' main stove. However the percentage of households who declared using the improved stove as their primary stove decreased with time (from 90% at the first monitoring 3 months after the baseline to 75% a year after) because of the declining conditions of the stove. There is a positive correlation between the declining use of the improved stove as a main stove and the declining overall condition of the stove (see paragraph III.d.i).

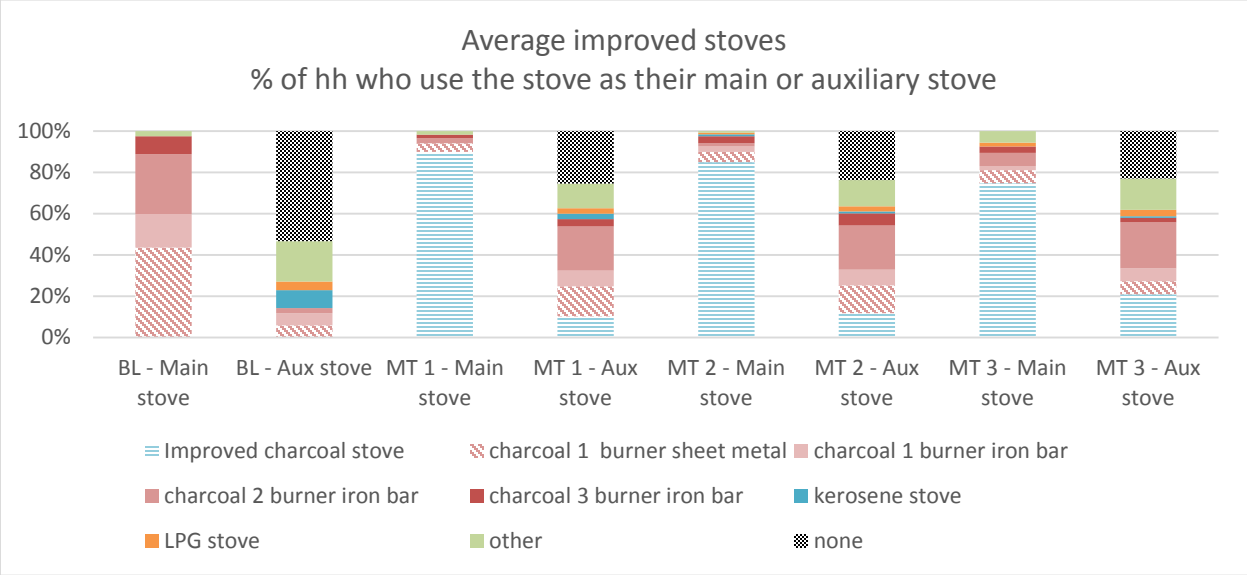


Figure 8: chart of the type of stoves used as main or auxiliary stove for cooking before (referred above as BL) and after (referred above as MT) the introduction of the improved cookstoves.

Detailed figures for each of the 8 stoves are available in Annex I.

vii. Stoves used for various dishes

In a context where multiple stoves and fuels are used together in the households, it is worth pursuing what kind of stoves are used for the typical dishes prepared often in Haiti. We looked at four of the most common dishes of the Haitian traditional cuisine:

- Rice and beans cooked together (*ri kolé*): a Haitian staple
- Soup: variations around sweet potatoes, carrots, cabbage
- Spaghetti: the classic pasta dish eaten for breakfast in Haiti
- Cornmeal (*Mayi Moulen*): another Haitian staple, simple cornmeal with garlic and shallots

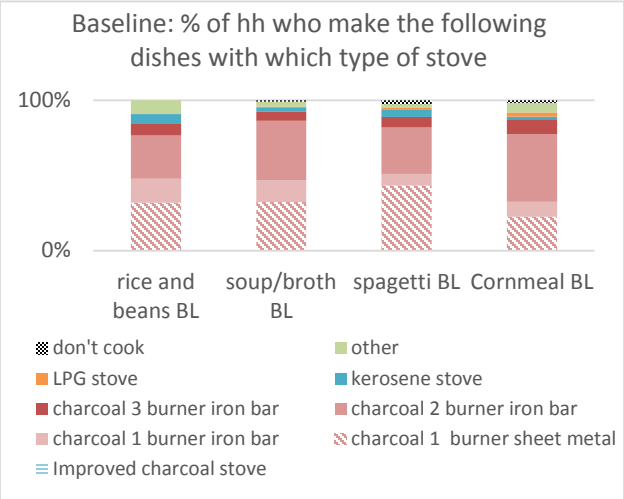


Figure 9: details of the type of stoves used in the baseline situation to make Haitian dishes

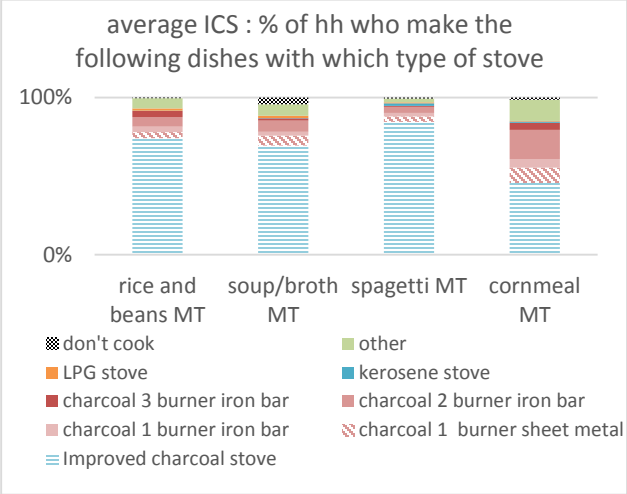


Figure 10: details of the type of stoves used to make Haitian dishes after the introduction of the improved cookstoves

Almost all the households surveyed declared preparing those four dishes on a regular basis. After their introduction, the improved stoves were used to varying degrees by each family. 86% of them used the ICS for cooking spaghetti while only 45% of them use their ICS for cooking cornmeal. Since the time and heat needed to cook each of these various dishes is different these figures can give us some insight into the conditions under which users prefer the improved stoves vs. a different kind of stove. Addressing the latter could lead to increased rates of improved cookstove adoption. A focus group discussion with the users who declared they are not using the improved cookstove to prepare cornmeal would allow us to better understand why.

Detailed figures for each of the 8 stoves are available in Annex II.

viii. Quantitative use measurement with "Stove Use Measurement Systems" (SUMS)

Each of the 120 improved stoves studied were continuously monitored with a portable temperature logger strapped to the side of the stove taking one measurement every 10 minutes. The data was downloaded every 2 months on average. We computed the frequency of the stoves' use for each of the 6 periods (every two month during one year)

The SUMS were attached only to the improved stoves and not on the traditional stoves. Since each improved cookstove had a different temperature profile, it was difficult to identify with certitude the total cooking time. However days where the stoves were used can easily be distinguished from the ones where they were not used and so this parameter has been chosen to describe the stoves usage rate.

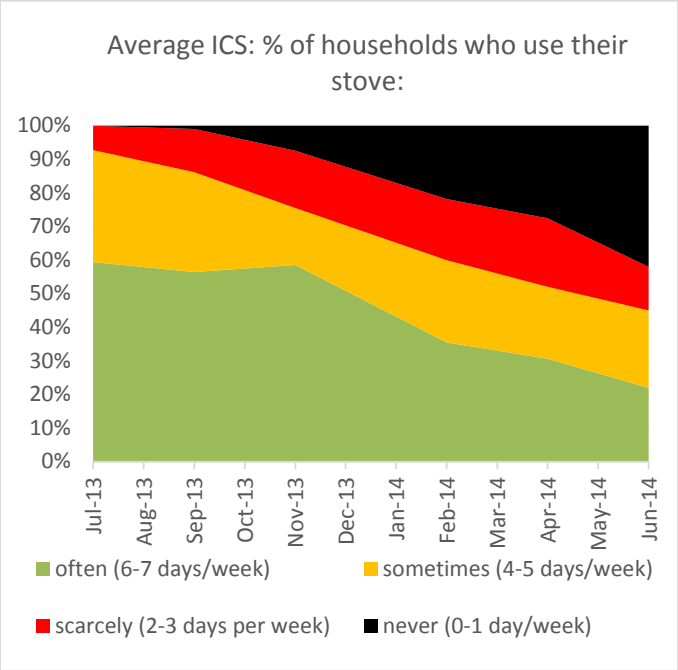


Figure 11: evolution of the stove use frequency during the one year study

The use of SUMS allowed for a much more accurate and precise understanding of the stove adoption patterns. On average, just after their introduction the stoves were used 6 to 7 days a week by only 60% of the households. This rate remains stable until November 2013 (5 months after the introduction of the stove) and starts declining steadily to reach 22% after one year.

There are significant differences between the ICS, please see Annex III for detailed figures.

USAGE RATE IS NOT BINARY

In scheme like carbon finance, usage rate are often assessed by a yes/no answer to the question "Are you still using your stove?". The SUMS clearly show that the usage pattern is more nuanced.

Systematically including this rather inexpensive system into carbon finance scheme would increase the precision and the reliability of the greenhouse gas reduction calculation.

b. Design

i. User perception of a good cookstove

Designing an improved cookstove is often a tradeoff between competing aspects. We thought it would be appropriate to start this section with the users' perception of what constitutes a good cookstove. Households provided their answers during the baseline survey before the introduction of the improved cookstoves.

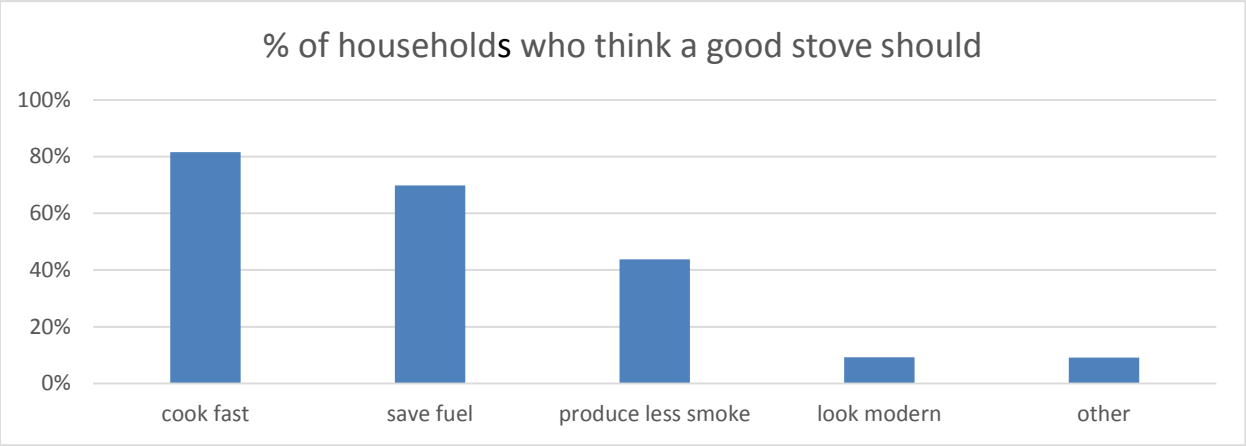


Figure 12: user perception of the qualities of "a good stove"

The most important criteria according to the users is the cooking speed, then the fuel savings, followed by emissions of the stove.

USERS VS DESIGNERS PRIORITIES

It is interesting to notice that users and designers priorities are not always aligned. Cooking speed, the highest priority of users is probably not the highest priority of the designers who are more concerned with fuel savings and emissions reductions. In order to increase the chances of stove adoption by Haitian households, stove manufacturers should strive to make their stoves cook as fast as or faster than the local traditional stoves.

ii. Modern look of the stoves

Surprisingly the imported stoves are not always reported by the users as looking "modern". The Men Recho is considered the most modern looking while imported stoves like the EcoZoom Prototype and the Prakti stove were not seen as modern. However, the modern look of the stoves was also not considered to be a priority criterion for the households.

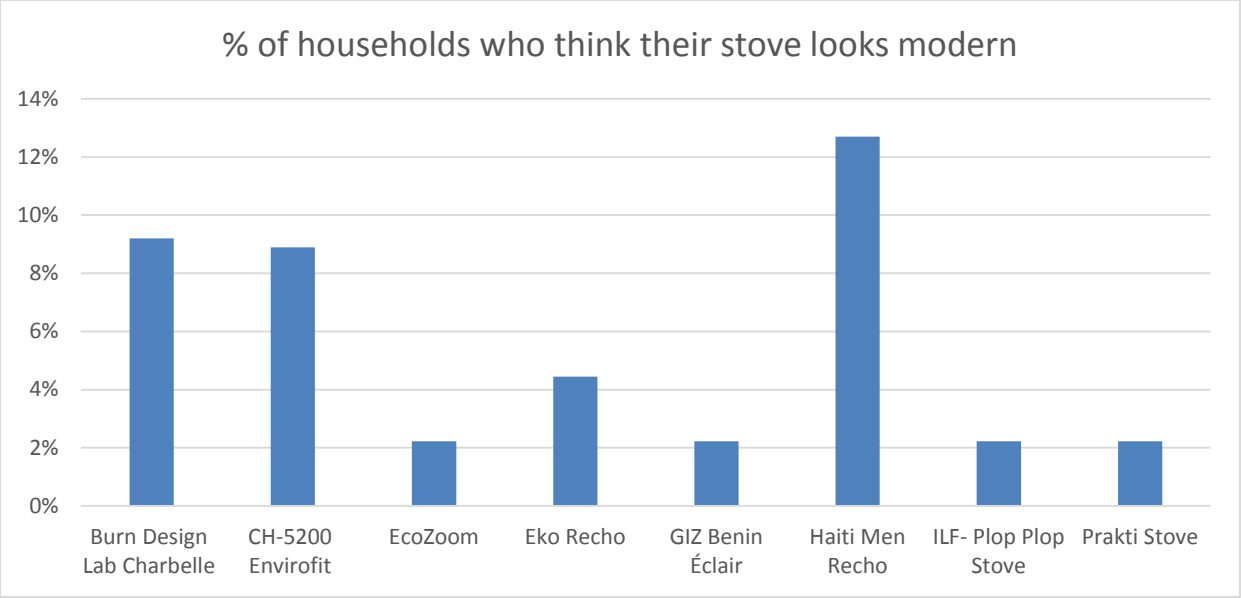


Figure 13: proportion of the users who think their stove looks modern

iii. Quantity of food stoves can prepare

Most of the households think that the quantity of food that can be cooked by the stoves is appropriate.

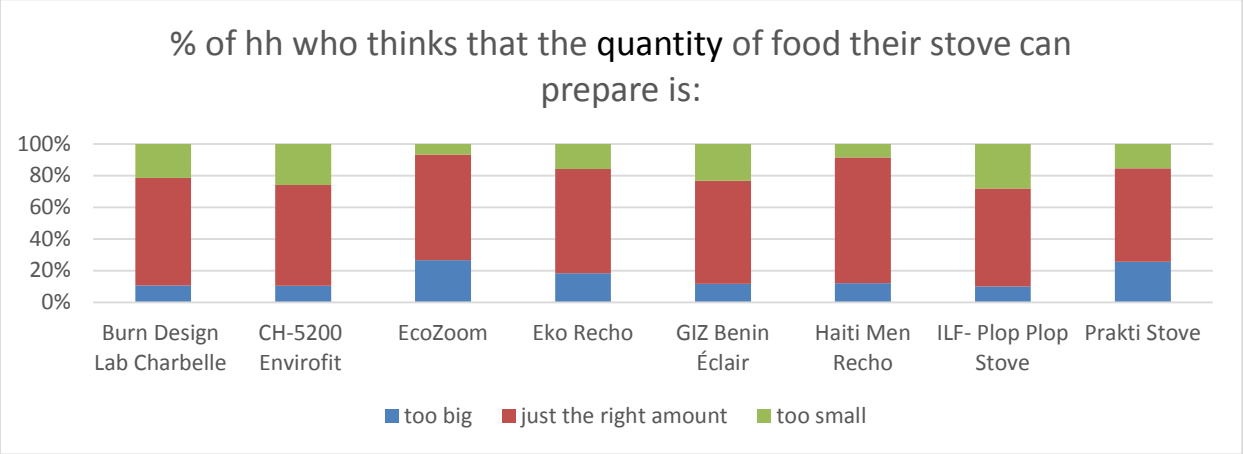


Figure 14: users' opinion about the quantity of food that the stove can prepare

More than 20% of the users see the Envirofit, the Éclair and the Plop Plop as too small. On the other hand more than 20% of the users see the EcoZoom Prototype and Prakti stoves as too big.

DOES SIZE MATTER?

Is important to note that the perception of the households is not directly connected to the size of the stoves. For example the Prakti combustion chamber (perceived as too big by 25% of the users) is about the same as the Plop Plop combustion chamber (which is perceived by 30% of the users as too small).

Investigating this apparent paradox could give some valuable information to the designers.

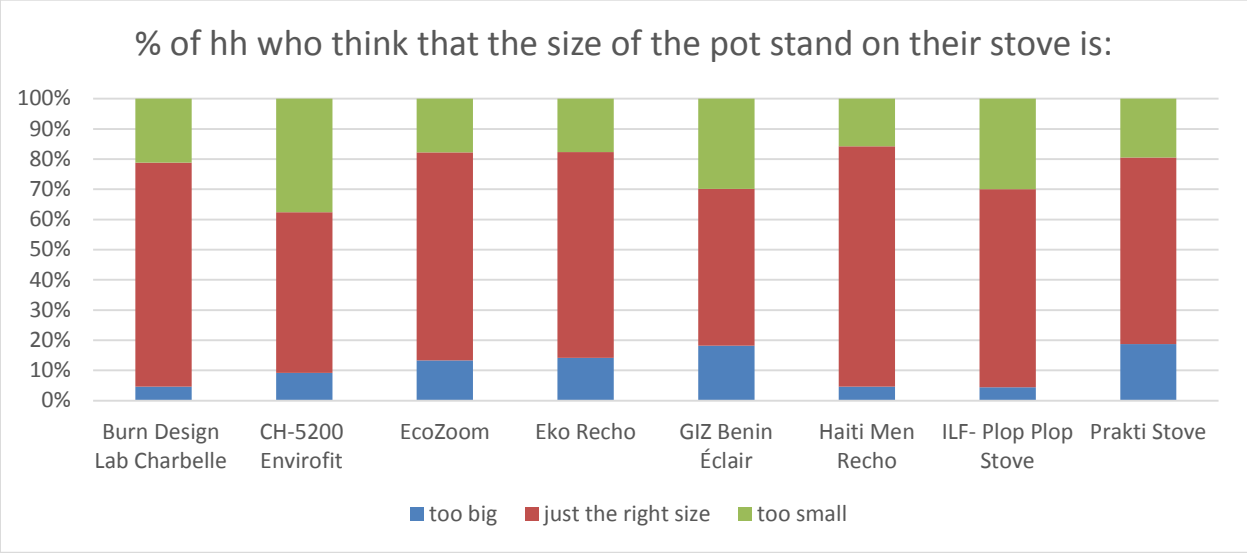
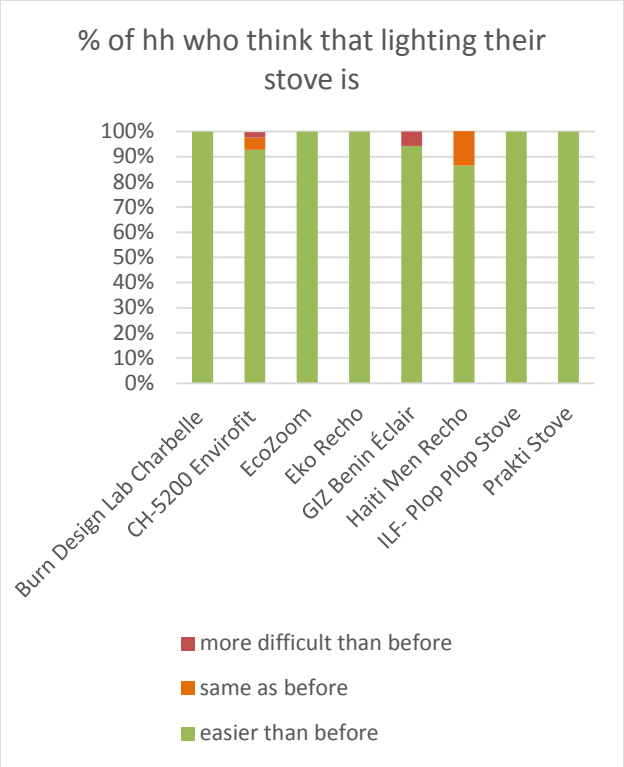


Figure 15: users' perception about the size of the pot stand

Here again most households think that the pot stands are the right size. The Envirofit stove is the exception with almost 40% of the users declaring the stands are too small.

iv. Ease of use

A stove well designed and well adapted to the local context should be perceived as easy to use. A majority of users did find the improved cookstove as being easier to light than their traditional stove. Most of them also found that cooking a meal was easier on their new stove.



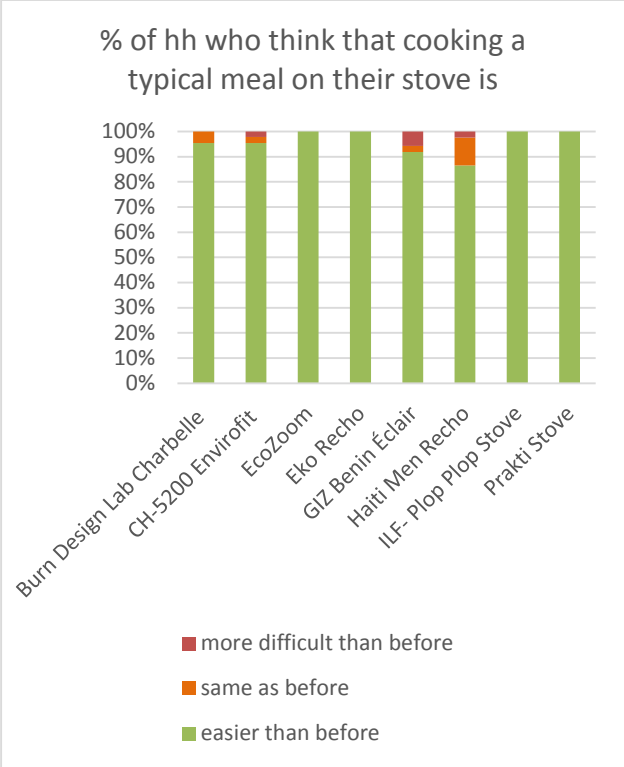


Figure 17: ease of lighting the stove

Figure 16: ease of cooking a meal on the stove

v. Improvements recommended by users

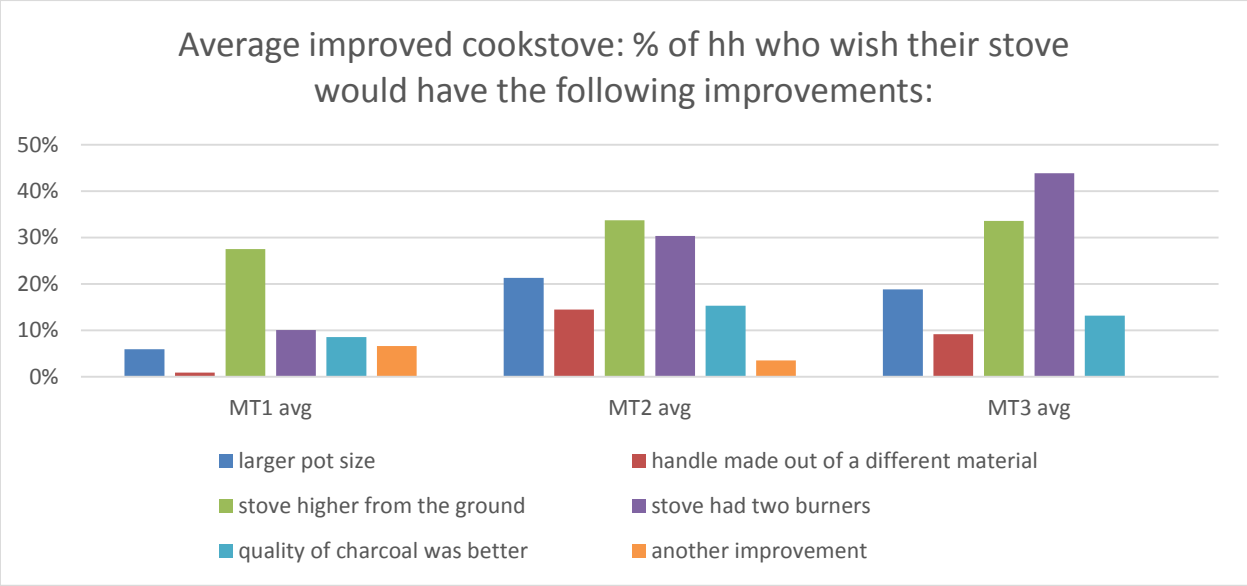


Figure 18: improvements recommended by users

The two most requested improvements by users were to have:

- the stove higher from the ground
- a stove with two burners

The percentage of users requesting these changes increased with time. Detailed figured for each stove are available in Annex IV.

OPTIMAL STOVES HEIGHT

Unlike some African countries, in Haiti cooks prefer stoves that don't lie too low on the ground because they often cook while standing up. This preference can be seen in the traditional stoves.

This should be taken into account by the manufacturers to increase the adoption of their stove in the Haitian context.

c. Fuel savings and Cooking speed

i. KPT results

The fuel savings were measured with a three day kitchen performance test. Depending on the fuels used by each household for their various cooking needs, charcoal, firewood, kerosene and LPG consumption were measured. To reduce variability in charcoal consumption and to enable a meaningful comparison, only the households using charcoal as their single cooking fuel are included in the calculations here.

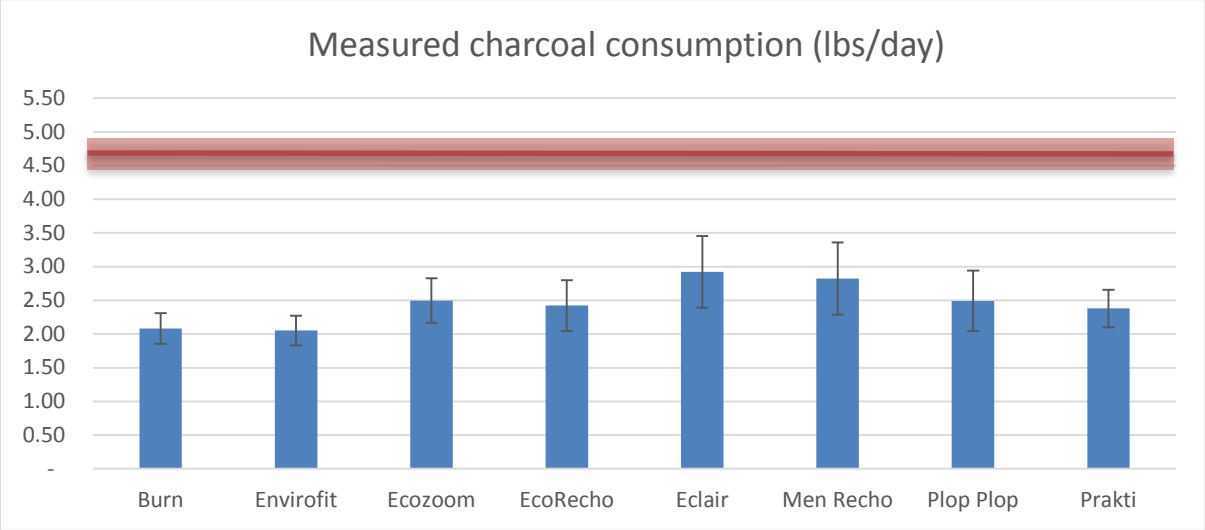


Figure 19: measured charcoal consumption

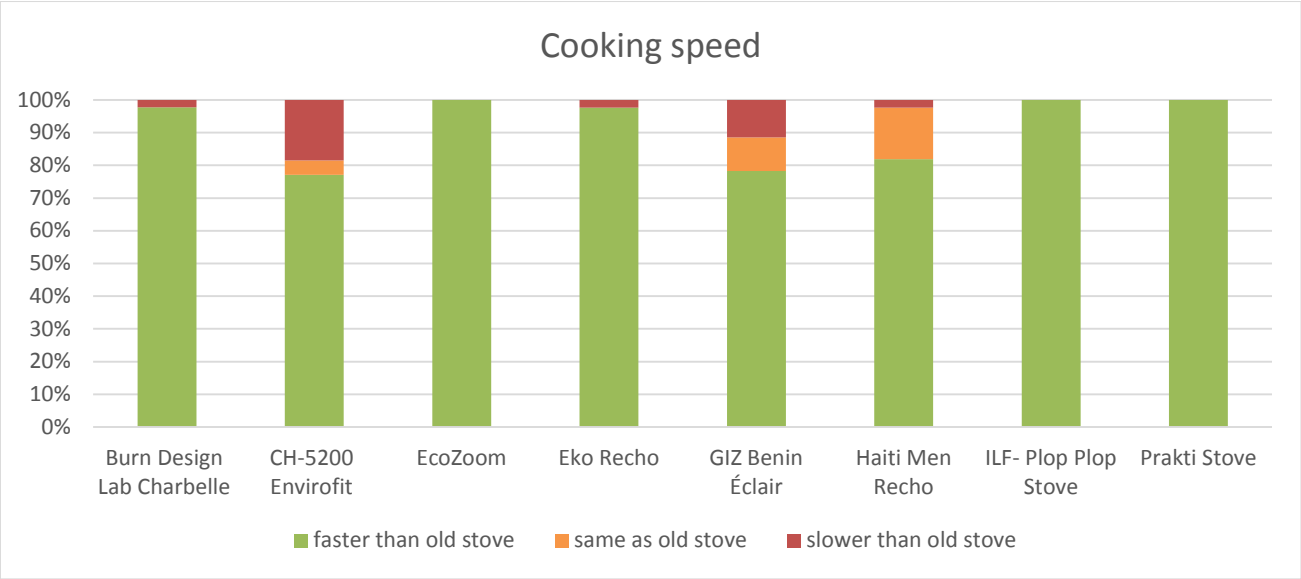
The blue bars represent the mean charcoal consumption in pounds per day measured during three sessions of three days each conducted at different times of the year (September 2013, March 2014 and June 2014). The error bars represent the 95% two-tailed confidence interval.

The red horizontal line represents the baseline consumption level and the 95% two-tailed confidence interval for the baseline consumption level. This figure comes from the National Baseline study conducted earlier by Papyrus consulting for the USAID ICTP/Recho Paw program. It used a different method (the respondents were asked to show the amount of charcoal they typically used which was then weighed).

The KPT clearly shows a significant decrease in charcoal consumption with the improved Cookstoves compared to the baseline level (about 50%). However because two different methods were used to assess baseline and project consumptions this figure should be considered with caution.

On average, the improved cookstoves have relatively comparable charcoal consumption with the Burn and Envirofit using the least charcoal and Éclair and Men Recho using the most amongst the eight stoves.

ii. Cooking speed



Most of the improved stoves were considered to be faster than the traditional stoves by an overwhelming majority of the users. The Envirofit, Éclair and Men Recho stoves were considered as being slower or comparable to their old stove by about 20% of their users.

d. Condition and maintenance

i. Overall condition of the stoves

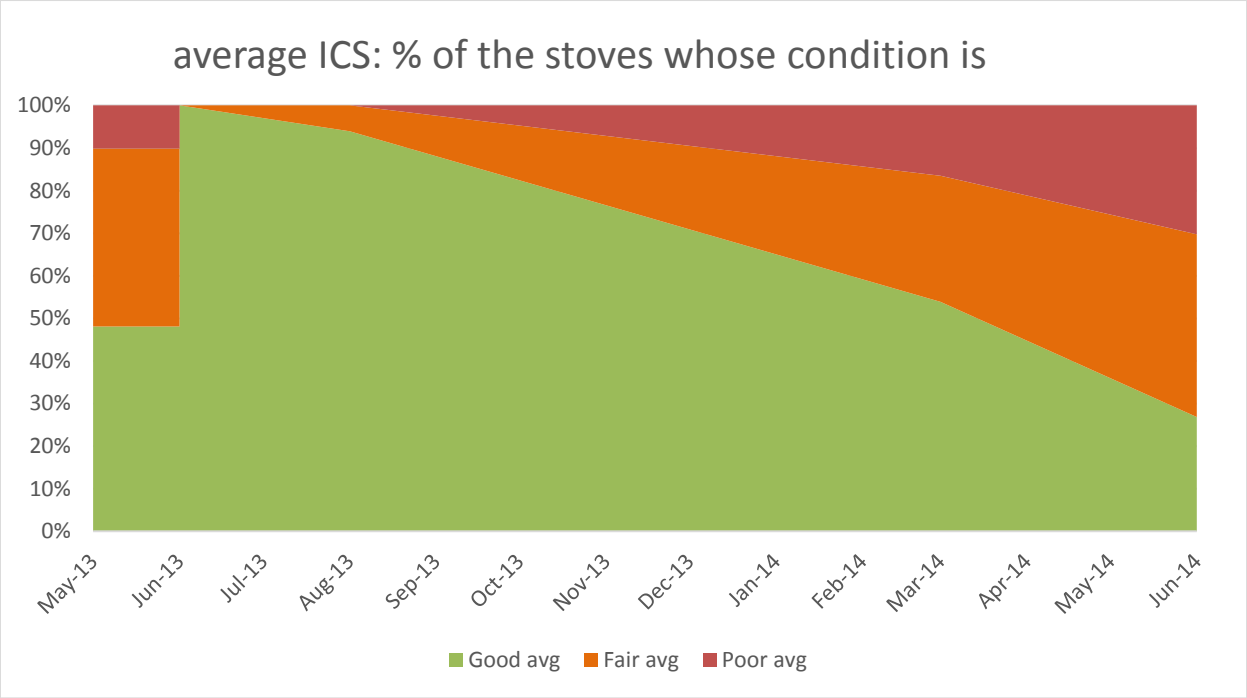


Figure 20: evolution of the improved stoves' condition during the study

The condition of the stove declined rather quickly. One year after their introduction only about 30% of the stoves were still in good condition. This is not surprising given the very saline atmosphere in Port-au-Prince which corrodes metallic objects quickly. Furthermore, water and food often spills onto the stoves during cooking even if the cooks know not to use water to clean the stoves.

To estimate their average lifespan we can assume that a household will buy a new stove only when it is in "poor condition" (i.e.: almost not usable anymore). Indeed stove in "fair condition" are damaged but remain usable. With this assumption, the average lifespan of the stove is the date for which 50% of the stove are in "poor condition". At the end of the one year study period only 30% of them are in poor condition. That means that the average life span of the improved cookstoves is greater than a year.

By comparison, the average lifespan of a round sheet metal traditional charcoal stove (*Recho twa pye*) is about 4 months while the more robust "iron bar" stove (*Zo requin*) lasts about a year. These figures comes from the baseline study published by Entrepreneurs du Monde - PALMIS Enèji with Initiative Développement (to be published in 2015).

Details for each of the improved stoves are presented in annex V.

ii. Stove parts damaged

Through this parameter, we explored which specific parts of the stove experienced the most damage.

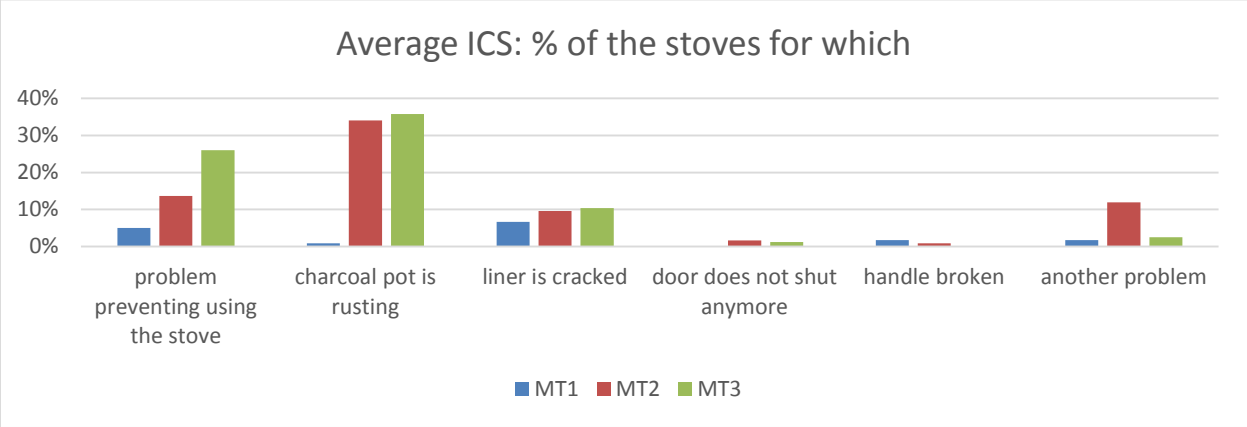


Figure 21: details of the parts damaged during the study

The corrosion of the combustion chamber appears to be the most common problem the stoves experienced over time. The doors and handles generally held up well.

Some households whose stoves were too damaged to be used anymore dropped from the study between the second and the third monitoring rounds. This explains why we do not see an increase in damages between the second and third monitoring rounds.

The results differ significantly between stoves, details are available in Annex VI.

iii. Frequency and type of maintenance operation done

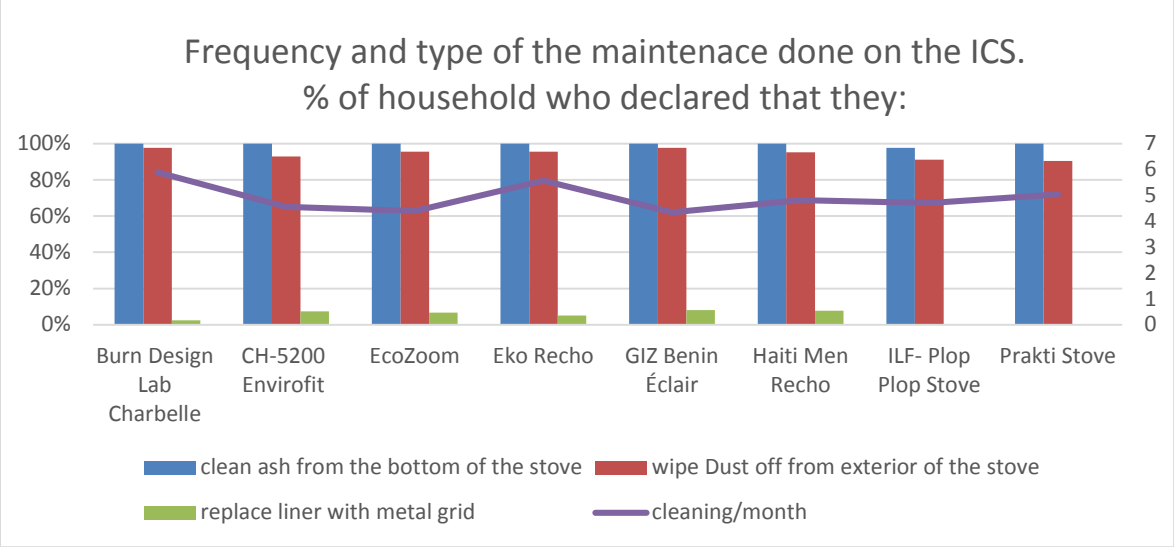
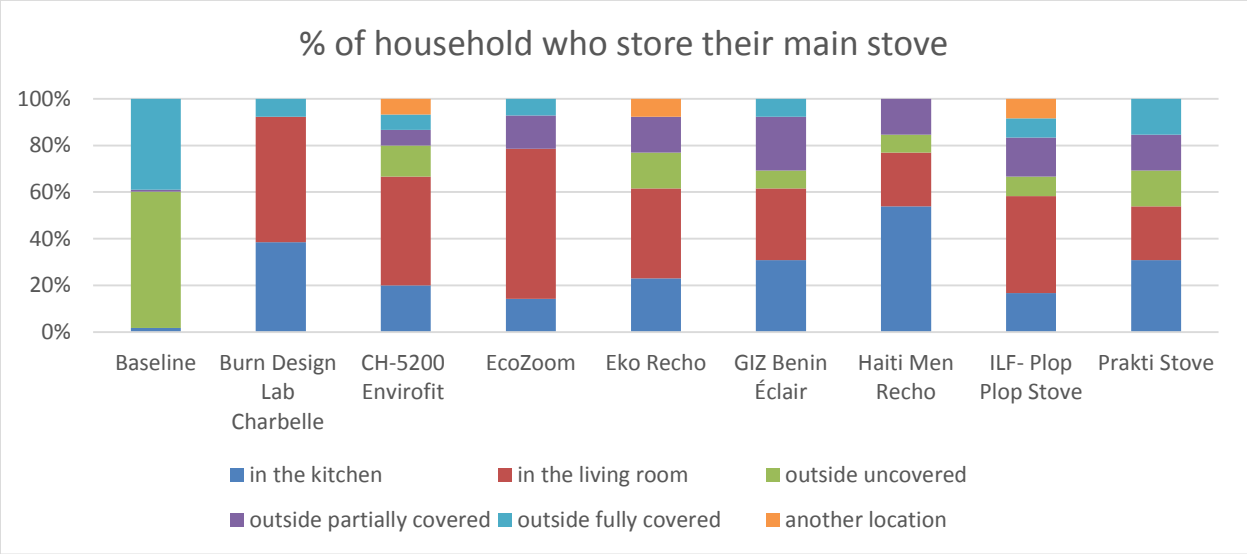


Figure 22: type and frequency of maintenance operations

Results show that the households clean the ashes and dust in their stove between 4 and 6 times per week. No significant differences were detected between the stoves.

iv. Storage of the improved cookstove

Stoves naturally suffer normal wear and tear during cooking, but improper storage conditions could also lead to a shortened lifespan. The chart hereunder shows where the stoves are stored.



The majority of the households really changed their habits from storing their traditional stove outside (covered or not) to storing their improved cookstove inside.

e. Health and safety impacts

In this section we examine the impact of the stoves on the safety and health of their users. We look at the frequency and cause of burn injuries that are unfortunately all too frequent when cooking with solids fuels on traditional stoves.

Then the emissions of the stoves and their health impacts are considered based on the point of view of the users and based on a quantitative assessment from Indoor Air Pollution meters.

i. Overall safety perception

We looked at the overall safety perception of the improved stove compared to the traditional stoves.

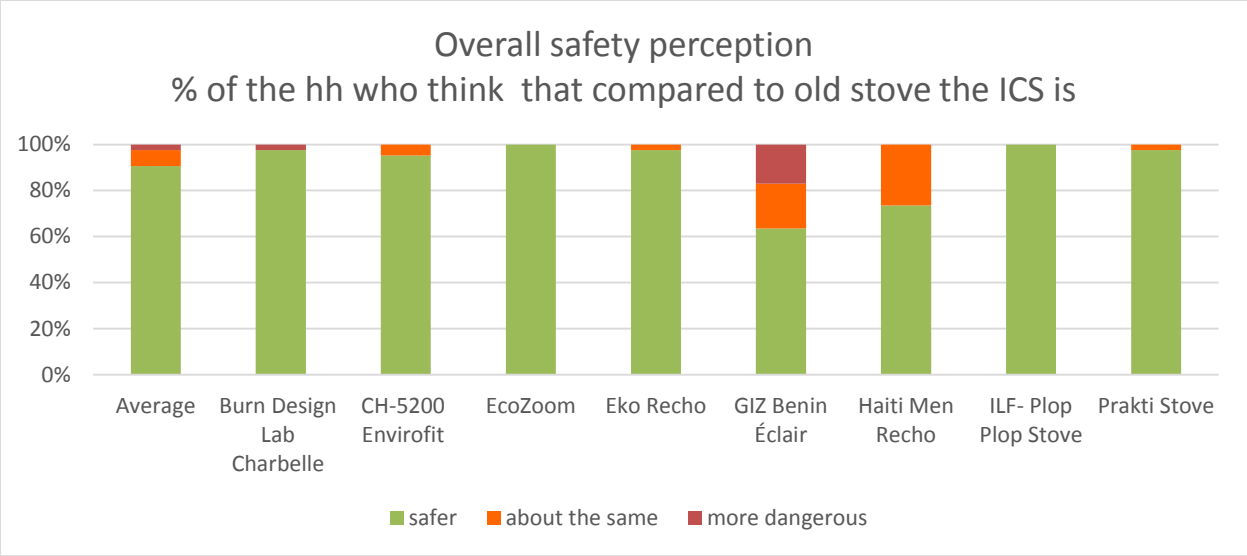


Figure 23: user perception of the improved stove safety level

The stoves are overwhelmingly considered safer than their traditional counterparts with the exception of the Éclair and the Men Recho. These 2 models were still considered safer by the majority of users, but not in as overwhelming numbers as the other stoves. Below some of the reasons why this may be the case are examined.

It should be noted that the modified Éclair included in the study had no handles which explains why they were considered by some as more dangerous than their traditional stove. This is not the case for the classic Éclair stove and if the stove was to be commercialized in Haiti a model with handles would be more appropriate.

The Men Recho was considered as safe as the traditional stove by 26% of its users while 74% judged it safer than their traditional stove. 0% viewed it as less safe than their traditional stove.

The figure below explains what the users considered as a potential safety hazard.

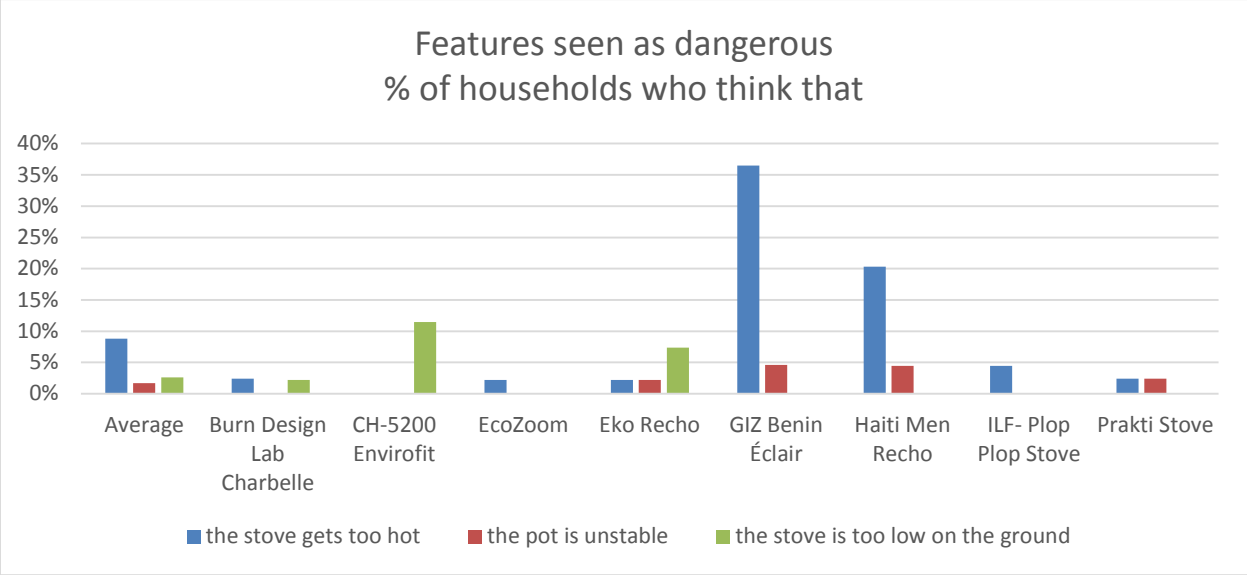


Figure 24: features perceived by the users as dangerous

For the Men Recho and the Éclair the fact that they get very hot while being used is the reason why they are considered as less safe by some households. The other stoves perform well with very low percentage of users reporting dangerous features.

On the flip side, users were asked why they thought their improved stoves were safer.

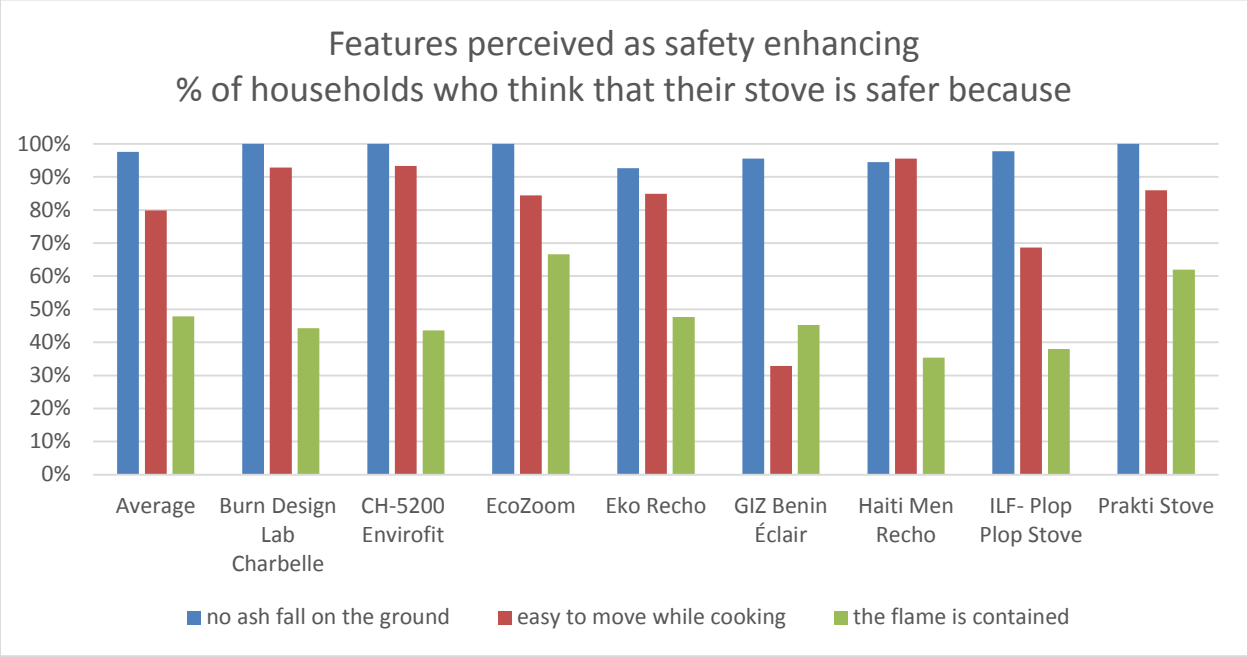


Figure 25: features perceived as enhancing the safety

Most users appreciate the fact that no ashes or hot coal fall on the ground compared to their traditional stoves. They also perceived the handles as being safety enhancing. The stoves with wooden handles received the highest rating in this regard. Because the Éclair did not have any handles it was not considered very convenient to move around. The ability of the EcoZoom Prototype and the Prakti Wouj to contain the flame well was appreciated by the users.

ii. Burn injuries

It was rewarding to see that the introduction of the improved cookstoves has dramatically reduced the occurrence of burn injuries. Because it had no handles this was not the case for the Éclair stove.

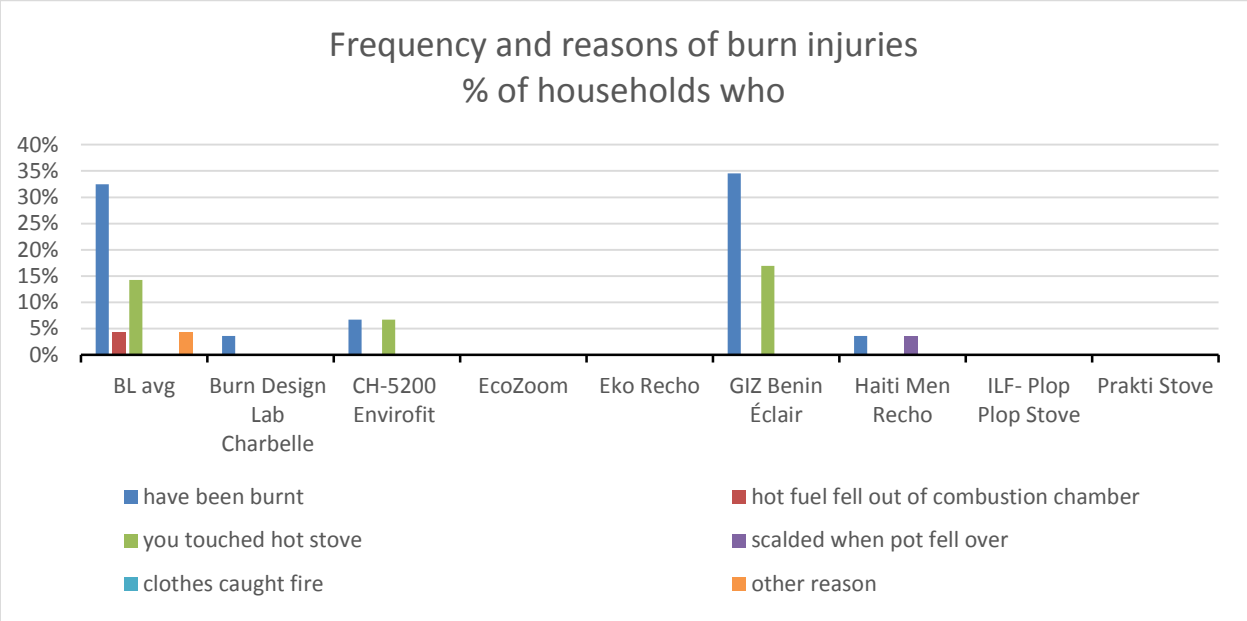


Figure 26: frequencies and reasons of burn injuries

iii. Perceived stove emissions and related issues

Aside from direct burn injuries, the other health hazard of cookstoves is related to emission exposure (primarily particulate matter or carbon monoxide).

We look first at how users perceived the change in emission quantity between the traditional and improved cookstoves.

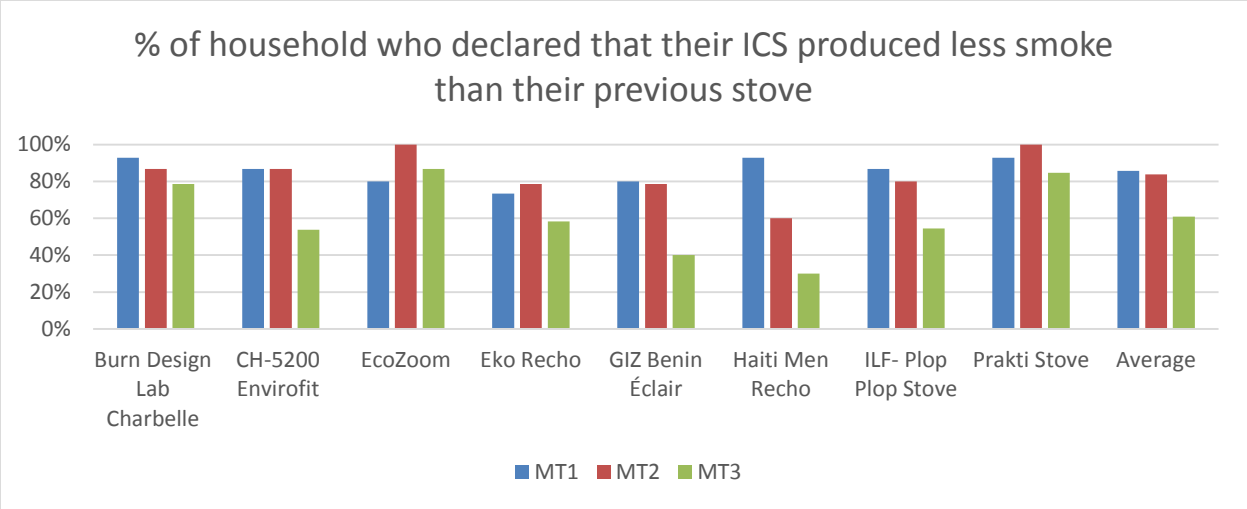


Figure 27: perceived stove emissions

Most of the households declared that their improved stoves reduced emissions when compared with their baseline stoves. However for most of the stoves, the percentage decreases with time probably because of the damage taken by the stoves.

This graph shows the self-diagnosed typical health impacts of emission exposure.

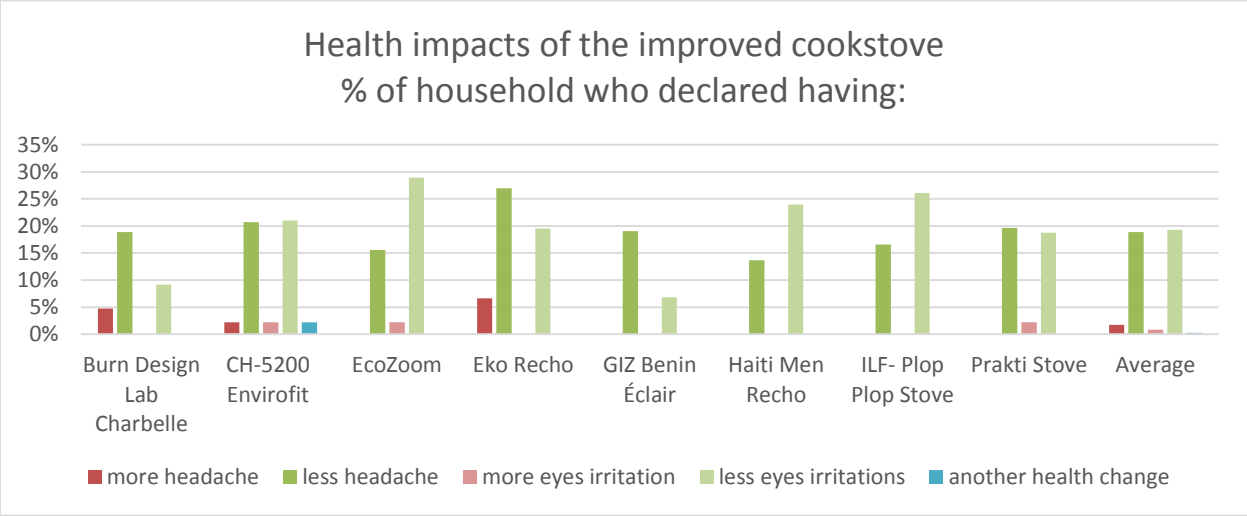


Figure 28: health impact of the improved cookstoves

About 20% of the users declared they noticed a significant decrease in the frequency of headaches and eye irritation. About 5% of the users reported an increase in headaches for the Burn and Eko Recho stoves.

iv. Quantitative carbon monoxide emissions

- *Data analysis:*

Indoor Air Pollution meters were used to monitor the emissions from the traditional and improved stoves. Charcoal stoves typically have low Particulate Matter (PM) 2.5µm emissions and a high Carbon monoxide (CO) emissions. That is why the focus here is put on carbon monoxide.

The IAP recorded the emissions during 24 to 48 hours in the households. Because there were only 4 IAP meters it was only possible to measure the emissions in a subsample of the 120 households (11 households in the baseline and 21 household with improved stoves).

The area of Barocia is located in the hills above Port-au-Prince, its inhabitant have access to surrounding forest and use firewood stoves combined with charcoal stoves. Because emission profile of firewood stoves (high PM, low CO) and charcoal stoves (low PM, high CO) differs widely and to reduce the dispersion of the data, measurements from the Barocia area are not taken into account here so that we can focus on charcoal users.

The maximum 15 minute average was chosen to represent the emissions. The 24h average would be influenced by the number of meals cooked on the stoves; the more meals the higher the emissions whereas cookstoves scarcely used would appear to be very clean. Looking at the maximum of the 15 minute average makes the measurement independent from the number of meals cooked and does not penalize stoves that are used more often.

- *Results*

The measurements show a 30% decrease in emissions of carbon monoxide when comparing the mean of the maximum 15 minutes average between traditional stoves and improved charcoal stoves.

The two tailed 90% confidence interval is displayed on the graph to show the uncertainties of the measurement. As anticipated from the start, the small sample size here yielded a rather large confidence interval. Given the high cost of the instruments it was not possible to extend the sample size in order to get more statistically significant results.

Nonetheless, a 30% decrease is a noticeable change that should be confirmed in a further study with a larger sample size.

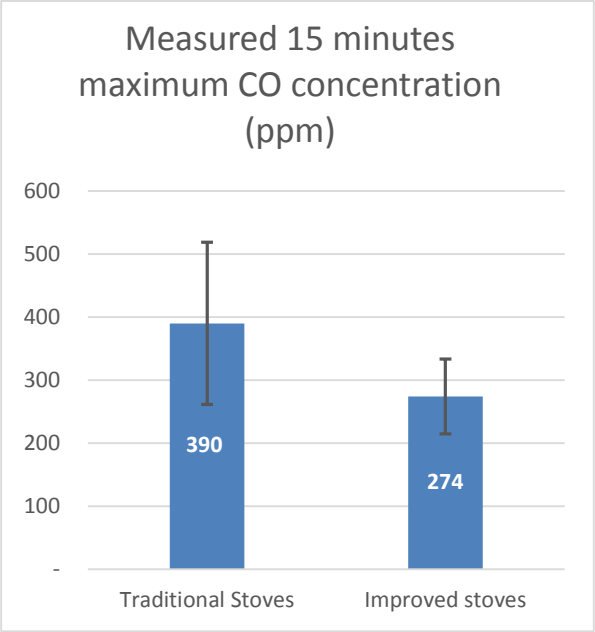


Figure 29: measured CO concentration above the stoves

f. Value and finance options

Pricing is definitely a key aspect for successful cookstove adoption. Even the best cookstove will not sell well if it is too expensive. Here we will look at the estimated value of the stove by their users. We will also look at the potential of micro-finance to alleviate the initial investment barrier.

i. Estimated price

The chart below demonstrates the difference between factory made and artisanal stoves quite clearly. Three months after their introduction, the former were all above 1000 HTG while the latter were under this value. It is interesting to notice that with time the estimated value of most of the stoves goes down significantly. The Prakti stove stands out here by remaining at rather constant evaluated price.

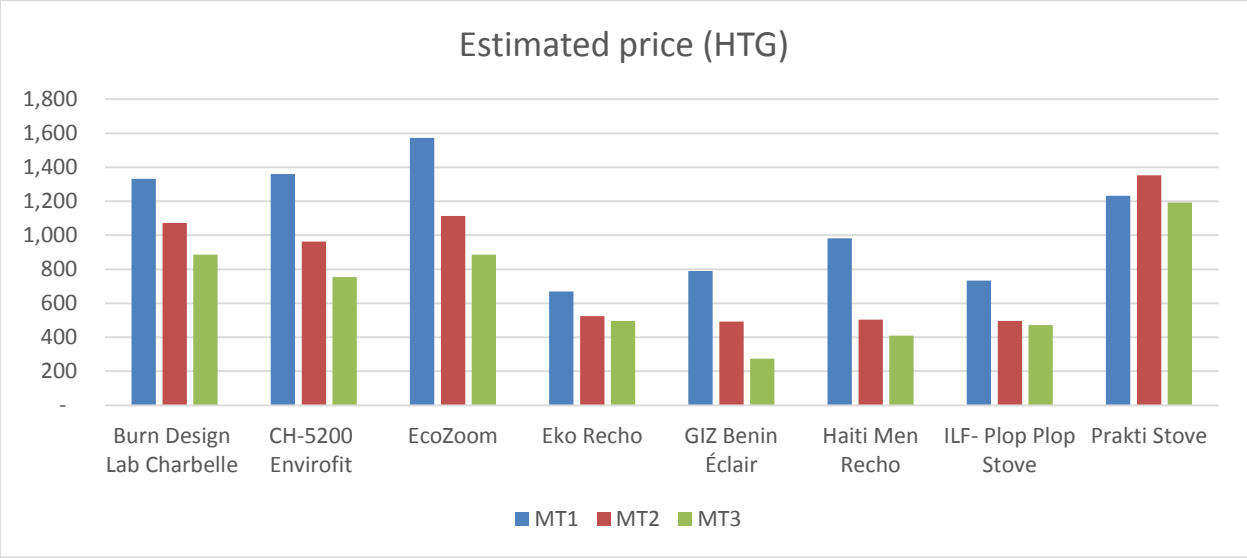


Figure 30: estimated price

For the four stoves available commercially in Port-au-Prince at the time of the study, the initial perceived price is above the actual retail value for the local stoves (Eco Recho, Men Recho, Plop Plop) while it is under the retail value for the imported stove (Prakti).

The study used the estimated price after 3 months (while the stoves are still in good condition) because it appeared to be the most relevant manner in which to assess how the actual retail price of a new stove compares to users' estimated price.

ii. Potential for microfinance

About 20% of the users estimated that their neighbor would be willing to take a loan to buy the stove. The Eco Zoom and Prakti are significantly higher with 38% and 34% respectively.

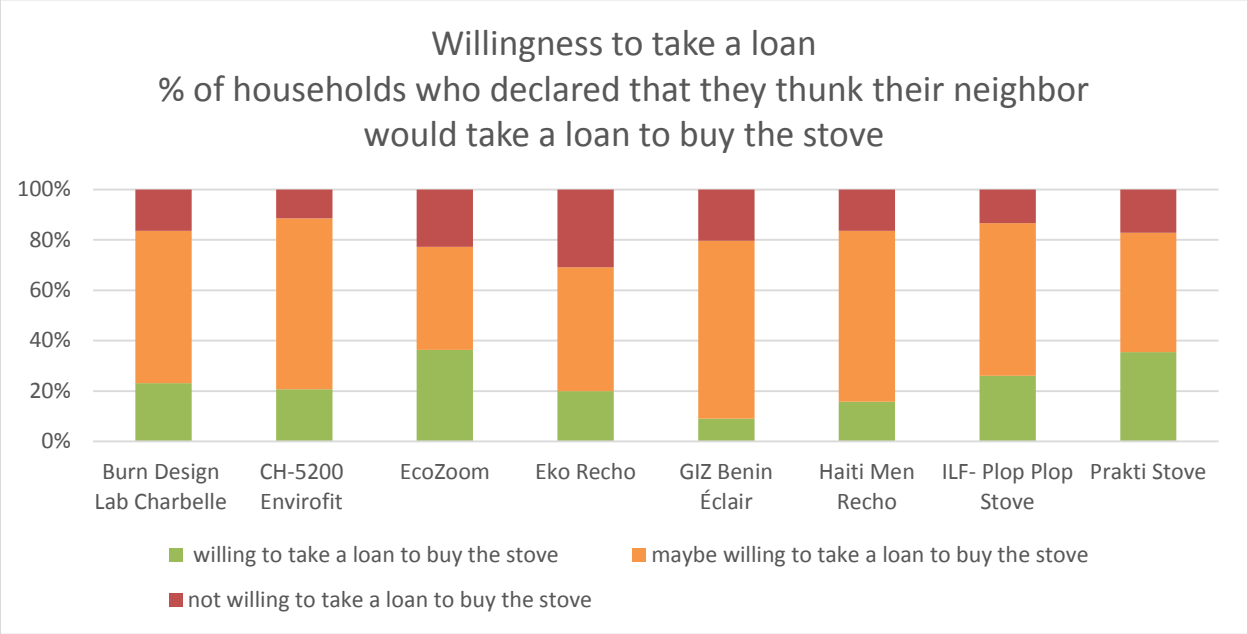


Figure 31: potential interest for payment plan

SUMMARY OF FINDINGS BY THEMES

- **Adoption:** A complex combination of stoves and fuels are used in Port-au-Prince. The improved cookstoves integrate well in this diversity, they become the main stove used for cooking but do not completely eliminate the use of traditional stoves. The usage rate drops significantly with time, the SUMS show that while 60% households used the ICS 6 to 7 days per week in the first 3 months, this figure dropped within one year to only 22%.

- **Design**: The ICS were overwhelmingly perceived as being easier to use than their traditional counterparts. The main design change requested by users were a 2 burners stove and that the stove be higher from the ground. Wooden handles were well appreciated. It is interesting to see that imported, factory made stoves do not always appear more "modern" than local stoves to the Haitians.

- **Fuel savings and cooking speed:** The real life measurement of fuel consumption showed a significant decrease in charcoal consumption by the improved stoves. Users also reported that the improved stoves cook the food faster than the traditional ones.

- **Condition:** After a year of use only 30% of the stoves remained in "good" condition. Most of the damage was due to the corrosion of the combustion chamber and to the cracks in clay based liners. Unlike the traditional stoves the ICS were mostly stored indoors offering them greater protection.

- **Safety and health impacts:** The ICS are perceived as being much safer than the traditional stoves because of the containment of the fuel and because of the reduced temperature of outside part. The occurrence of burn injuries were dramatically reduced. 20-30% of the users reported a decrease in headaches and eyes infections. The introduction of the ICS reduced the maximum 15 minute average emissions of CO by about 30%.

- **Value:** The user-estimated price of the stoves is higher for the imported stove than for the local ones. However it is above the actual retail price for the local stoves but below retail price for imported one. 20% of the users would be willing to considered borrowing to buy the ICS.

SUMMARY OF FINDINGS BY STOVE

- **Burn Design: Jikokoa**

Assets: This stove has an adoption rate comparable to the other stoves and it is perceived as looking modern by a higher than average percentage of the users. They think it much easier to use and faster than the traditional stoves. The stove also had one of the lowest charcoal consumptions measured over the one year of the study. The stove is much safer than traditional stoves and allowed an important reduction in burn injuries. The users estimated retail price was high at 1330 HTG (US$ 30) after 3 months of use.

Could be improved: The conditions of the stove degraded slightly faster than for the other stoves with damage mainly of the combustion chamber (corrosion) in spite of the fact that the stove was mostly stored indoors (90% of users). The users requested a two burner version that would be higher from the ground.

- **Envirofit: CH-5200**

Assets: The Envirofit stove has an adoption rate higher than the average of the other stoves and is perceived as looking modern by a higher than average % of the users (9%). They think it is much easier to use than the traditional stoves. The stove had one of the lowest charcoal consumptions measured over the one year of the study. Overall the stove was considered safer than traditional stoves (but being too low to the ground was considered by some as a safety risk). It allowed a significant reduction in burn injuries although some burns injuries still occurred. The user-estimated retail price was high at 1370 HTG (US$ 30) after 3 months of use.

Could be improved: The conditions of the stove degraded slightly faster than for the other stoves with damage mainly to the combustion chamber (corrosion) in spite of the fact that the stove was mostly stored indoors (70% of users). The users requested a two burner version (50% of them) that would be higher from the ground (40%). 38% of the users reported that the pot stands were too small. Almost 20% of the users report it as slower than their traditional stove.

- **EcoZoom Prototype:**

Assets: This stove had the highest adoption rate of the eight stoves tested although it was not perceived as looking modern. Users thought it was much easier to use and faster than the traditional stoves. The charcoal consumption of the stove was comparable to the average of the other stoves. The stove is much safer than traditional stoves, which resulted in an important reduction in burn injuries. Of all the stoves tested here the EcoZoom Prototype is the one which remained in the best condition (with damage due to the corrosion of the combustion chamber). It was stored indoor by 80% of users. This stove also had the highest user-estimated price at 1600 HTG (US$ 35) after 3 months of use.

Could be improved: The users requested a two burner version (40% of them) that would be higher from the ground (35% of the users).

- **Ecorecho:**

Assets: The Ecorecho stove has an adoption rate comparable to the other stoves and is perceived as looking modern by 5% of the users. They think it much easier to use and faster than the traditional stoves. The charcoal consumption of the stove was comparable to the average of the other stoves. The stove is much safer than traditional stoves, which allowed for an important reduction in burn injuries. The user-estimated retail price was low at 700 HTG (US$ 15) after 3 months of use but remain higher than the actual retail price of the stove.

Could be improved: The condition of the stove degraded slightly faster than the other stoves with damage mainly to the clay liner and to the combustion chamber in spite of the fact that the stove was mostly stored indoors (60% of users). It should be noted that the Ecorecho stove now has an improved clay formulation so the problems noticed during the study might not occur with the newer version of the stove. The users requested a two burner version (40% of them) that would be higher from the ground (35% of the users).

- **Éclair stove**

The Éclair stove used in this study were quickly modified for the Haitian context and did not receive any handles. This may explain some of the issues reported by the users. The Éclair stove generally comes with handles.

Could be improved: The Eclair stove had a rather low adoption rate, 80% of the stoves were not used anymore after one year. It did not appear very modern to the users. 8% of them thought the stove more difficult to use or comparable to their traditional stoves. The

stove also had a charcoal consumption higher than the other stoves. 20% of the users thought the stove was slower or comparable to their traditional stove. The stove condition degraded faster than the other stoves with damage mostly to the combustion chamber. Handles were requested by most users. The level of burn injuries remained comparable to the traditional stoves, 40 % of the users found the stove to be equally or more dangerous than their traditional stove. The user-estimated retail price was 800 HTG (US$ 18) after 3 months of use.

- **Men Recho**

Assets: The Men Recho stove had the highest percentage of users who thought it looked modern (12%), probably because of the enamel. Stove condition remained with the average of the other stoves and the main damage was due to the corrosion of the combustion chamber although the stove was stored indoors by 60% of the users. The user-estimated retail price was 1000 HTG (US$ 22) after 3 months of use, the highest among locally made stoves.

Could be improved: The adoption rate was lower than the average of the other stoves. 13 % of users thought the stove was similar or more difficult to use as their traditional stove. The charcoal consumption was among the highest measured with the KPT. 18 percent of the users found the stove to be comparable or slower than their traditional stove. 37% of the users found the stove similar or worse than their traditional stove as far as safety, a few users got burnt while using the stove.

- **Plop Plop**

Assets: The Plop Plop stove has an adoption rate higher than the average and was unanimously found to be easier to use and light than the traditional stoves. The stove was considered faster than the traditional stove. The charcoal consumption of the stove was comparable to the average of the other stoves. The stove is much safer than traditional stoves, resulting in an important reduction in burn injuries. The user-estimated retail price was 730 HTG (US$ 16) which is higher than the actual retail price of the stove.

Could be improved: The stove did not appear very modern to the users. They requested a two burner version (60% of the users) that would be higher from the ground (27% of the users). Handles in another material would also be appreciated. The stove condition was better than average until the 9 months mark and then dropped sharply to worse than average at one year. The main damage was due to the corrosion of the combustion chamber although the stove was stored indoors by 60% of users.

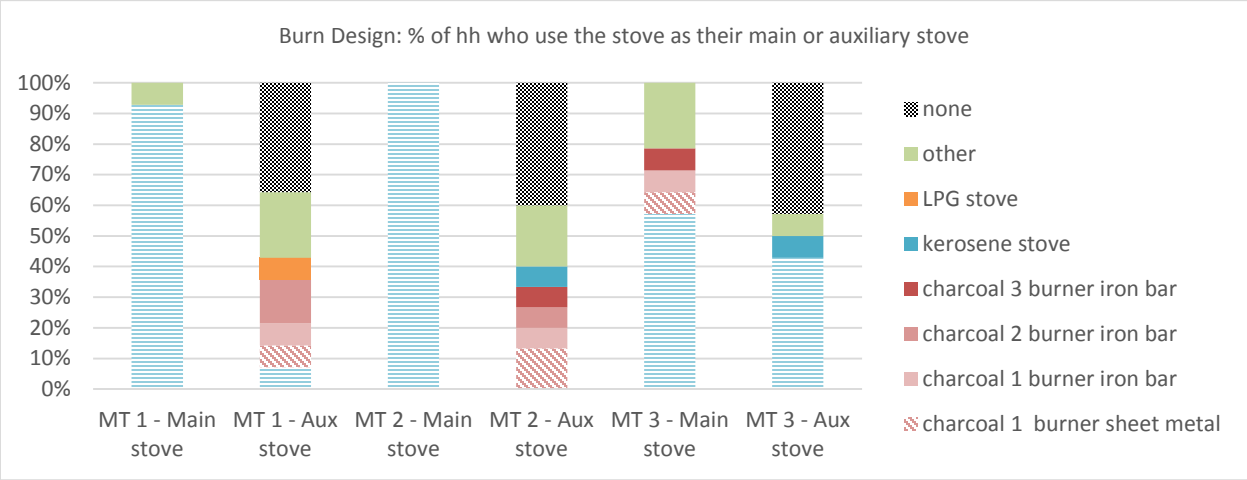
- **Prakti**

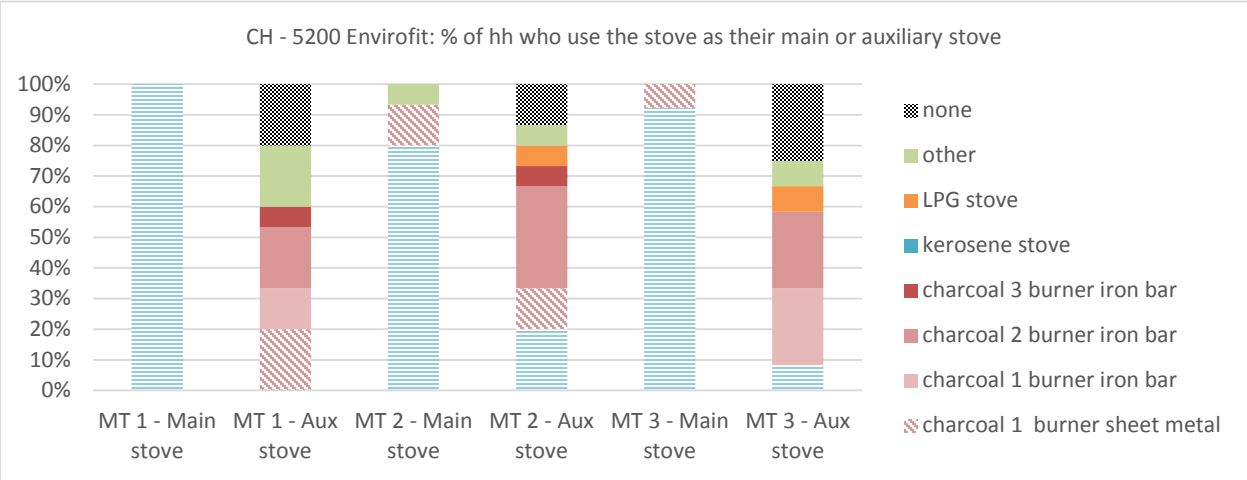
Assets: The Prakti stove has an adoption rate higher than the average and was unanimously found to be easier to use and light than the traditional stoves. The stove was considered faster than the traditional stove. The charcoal consumption of the stove was comparable to the average of the other stoves. The stove is much safer than traditional stoves, resulting in an important reduction in burn injuries. The stove condition remained better than most of the other stoves during the study. The main damage were due to the corrosion of the combustion chamber.

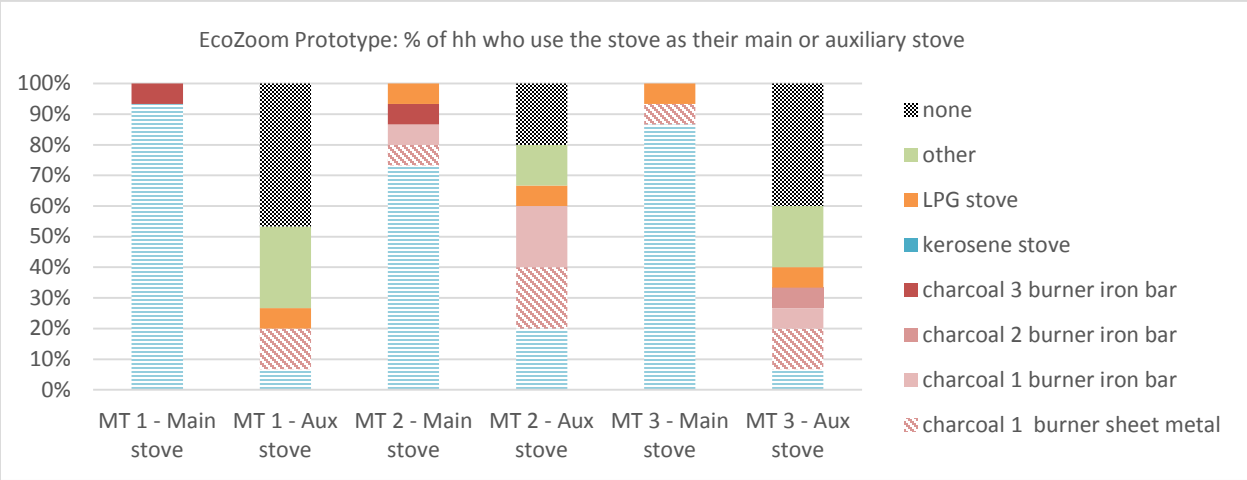
Could be improved: The users requested a two burner version (38% of the users) that would be higher from the ground (54% of the users).The stove did not appear very modern to the users. The user-estimated retail price was high at 1230 HTG but remains lower than the actual retail price of the stove.

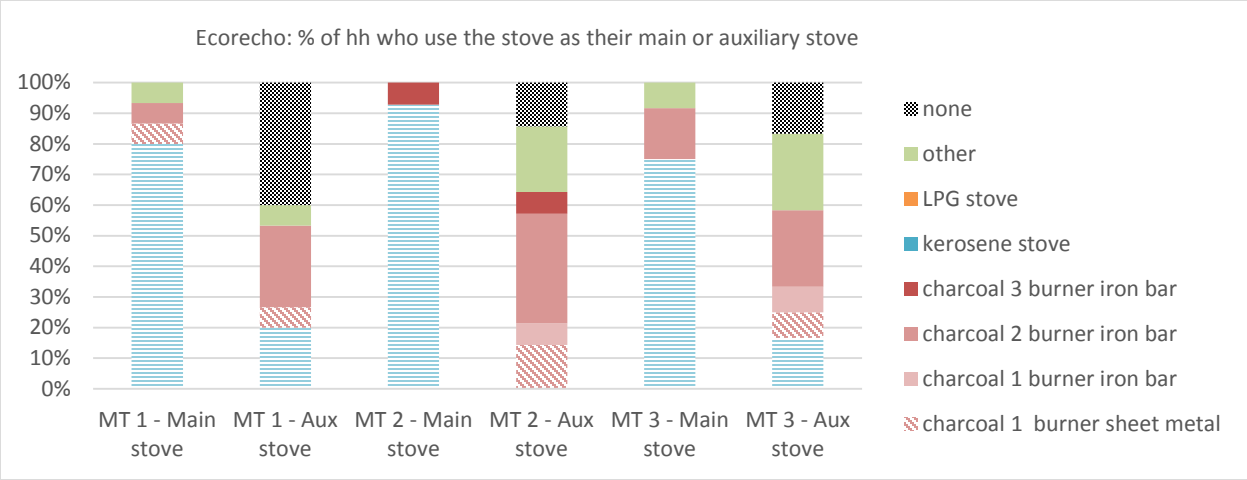
ANNEX I: PRIMARY STOVES

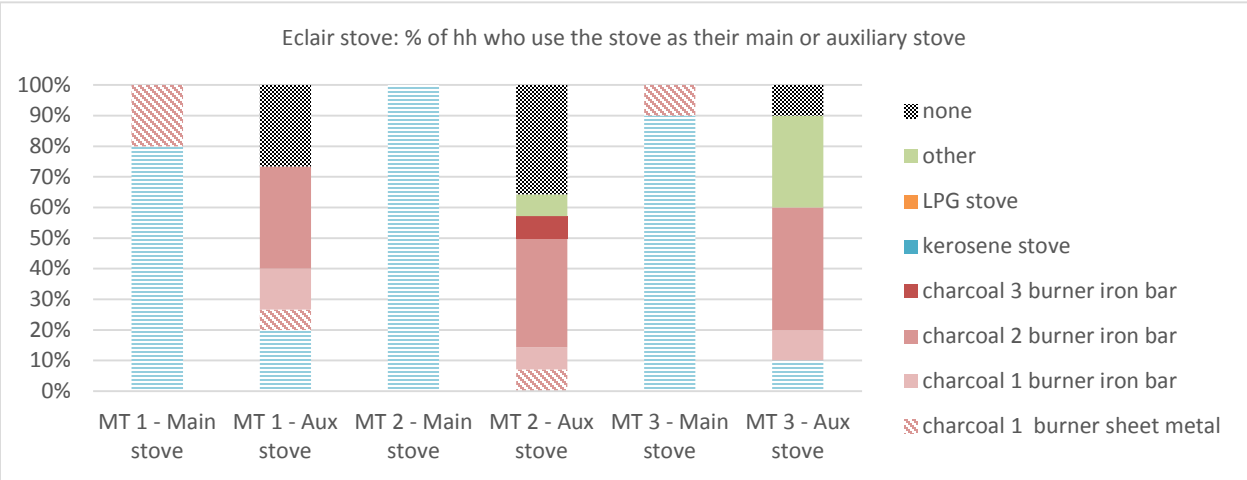
This annex provide the details of the type of stove used by the households who received the improved cookstoves.

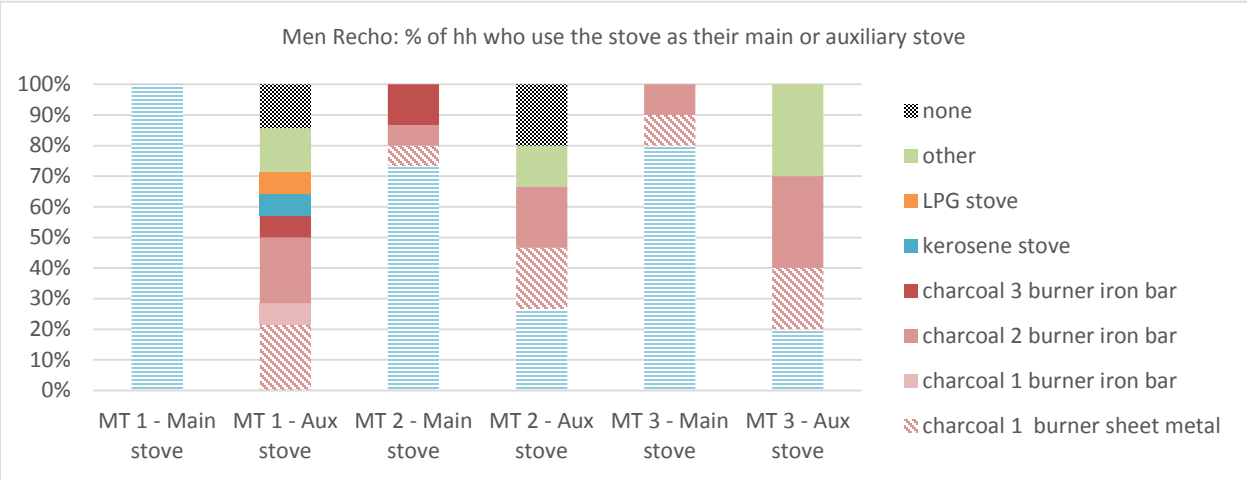


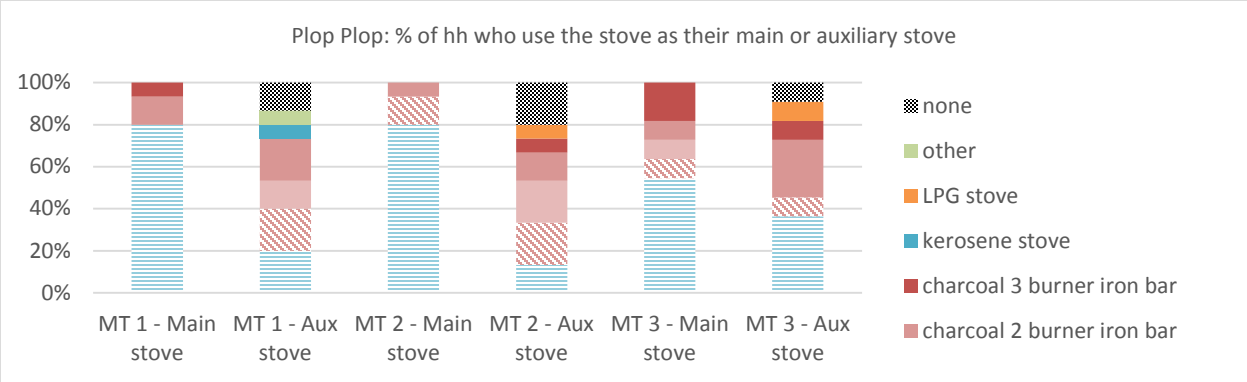


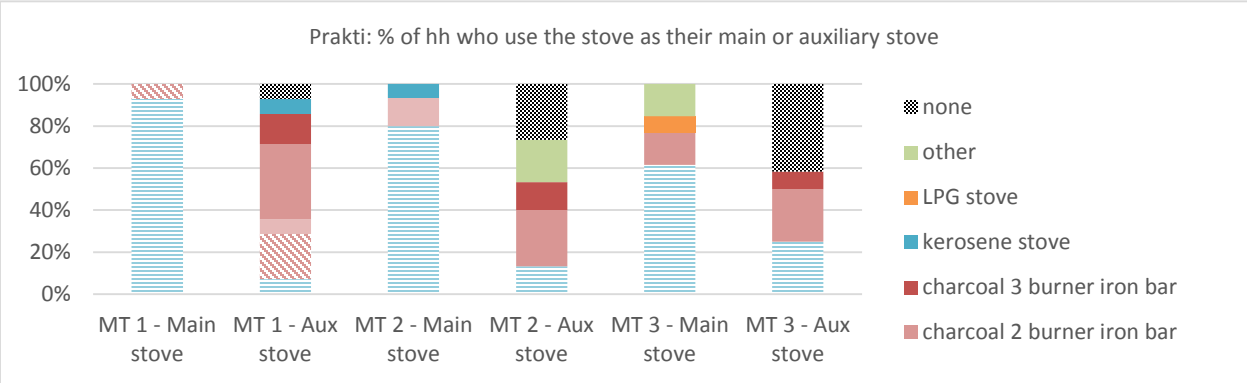



Ecorecho: % of hh who use the stove as their main or auxiliary stove
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MT 1 - Main stove
MT 1 - Aux stove
MT 2 - Main stove
MT 2 - Aux stove
MT 3 - Main stove
MT 3 - Aux stove
none
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar
charcoal 1 burner iron bar
charcoal 1 burner sheet metal


Eclair stove: % of hh who use the stove as their main or auxiliary stove
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MT 1 - Main stove
MT 1 - Aux stove
MT 2 - Main stove
MT 2 - Aux stove
MT 3 - Main stove
MT 3 - Aux stove
none
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar
charcoal 1 burner iron bar
charcoal 1 burner sheet metal

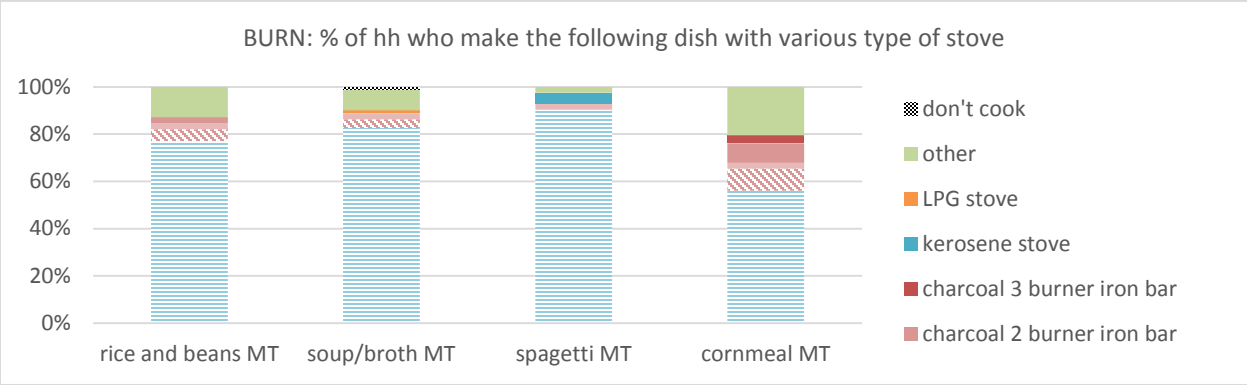

Men Recho: % of hh who use the stove as their main or auxiliary stove
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
MT 1 - Main stove
MT 1 - Aux stove
MT 2 - Main stove
MT 2 - Aux stove
MT 3 - Main stove
MT 3 - Aux stove
none
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar
charcoal 1 burner iron bar
charcoal 1 burner sheet metal

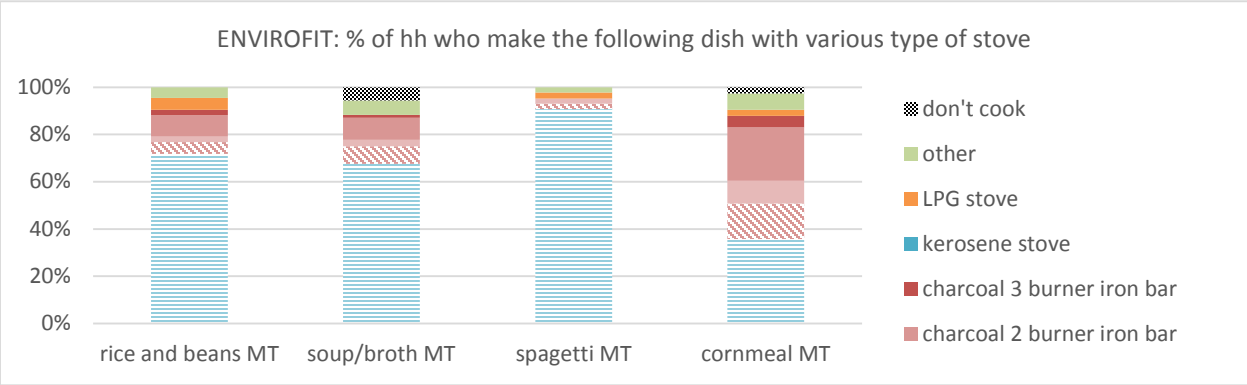

Plop Plop: % of hh who use the stove as their main or auxiliary stove
100%
80%
60%
40%
20%
0%
MT 1 - Main stove
MT 1 - Aux stove
MT 2 - Main stove
MT 2 - Aux stove
MT 3 - Main stove
MT 3 - Aux stove
none
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

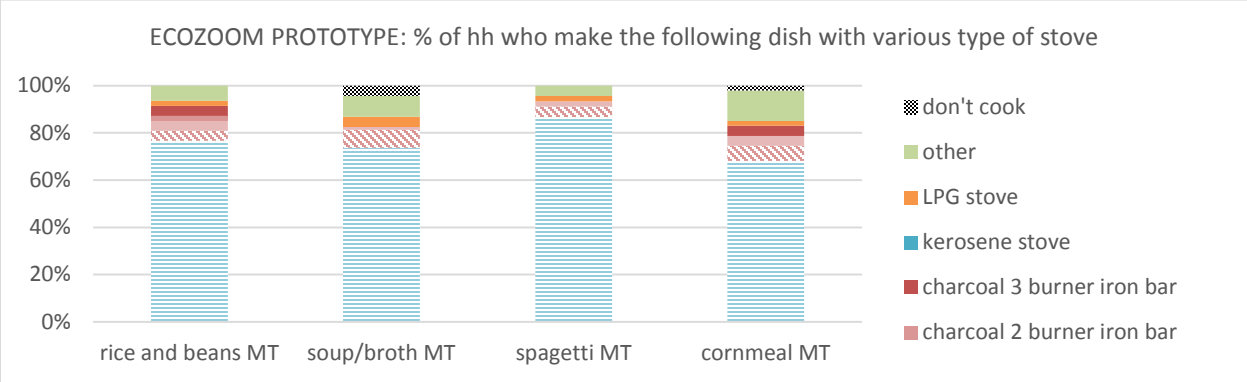

Prakti: % of hh who use the stove as their main or auxiliary stove
100%
80%
60%
40%
20%
0%
MT 1 - Main stove
MT 1 - Aux stove
MT 2 - Main stove
MT 2 - Aux stove
MT 3 - Main stove
MT 3 - Aux stove
none
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

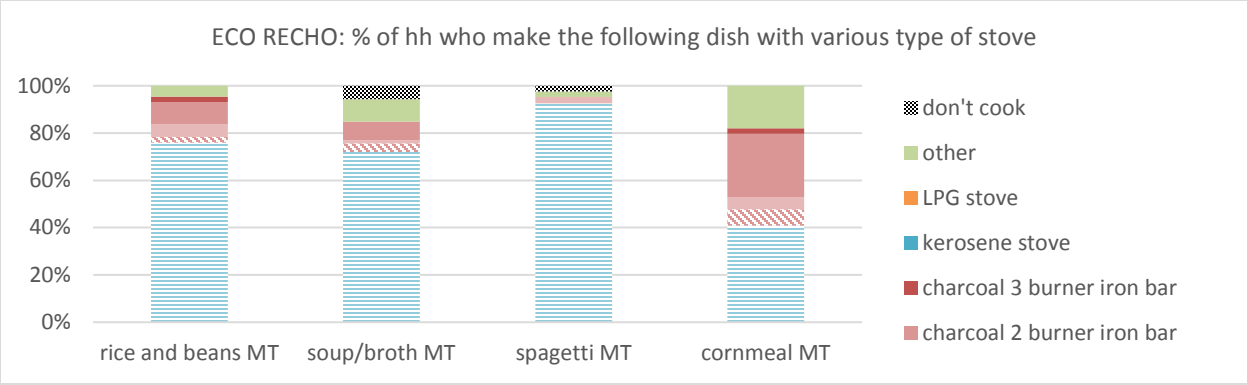
ANNEX II: DETAILS REGARDING STOVE USED FOR COOKING VARIOUS DISHES

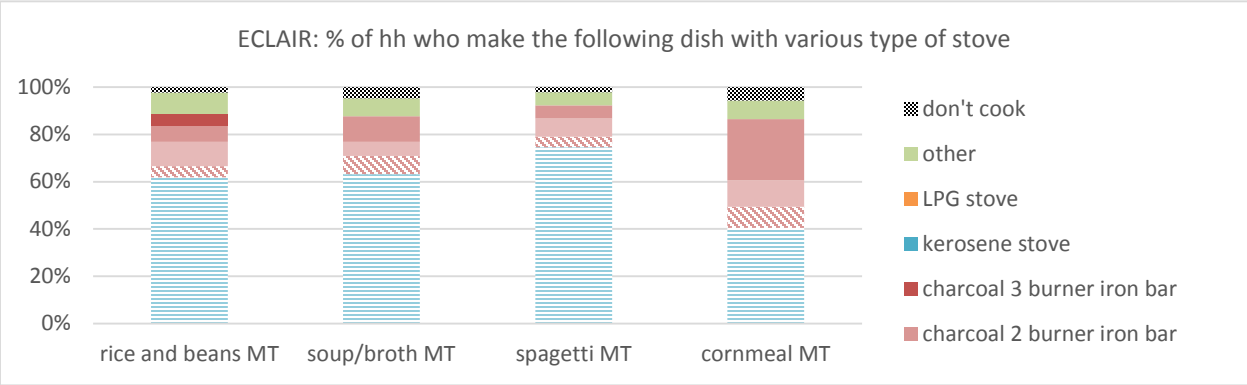
This annex provide details on the type of stoves used to cook four typical Haitian dishes.

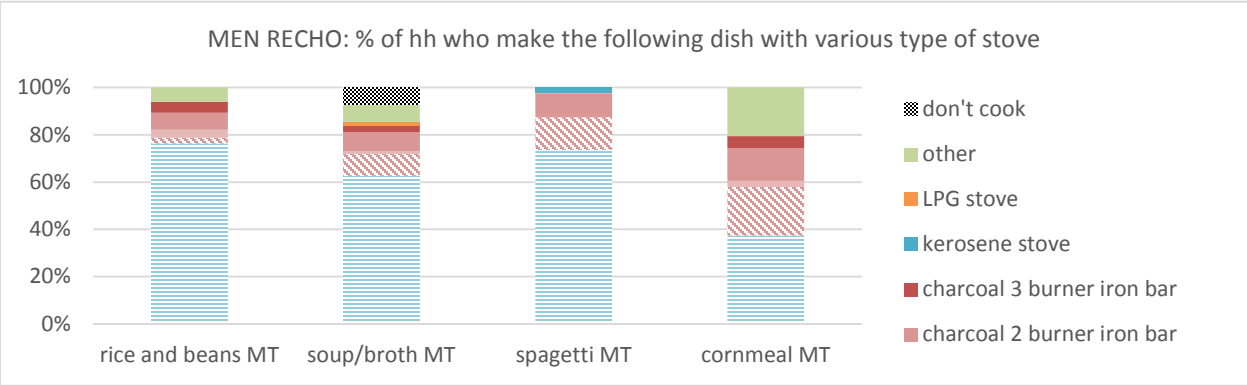


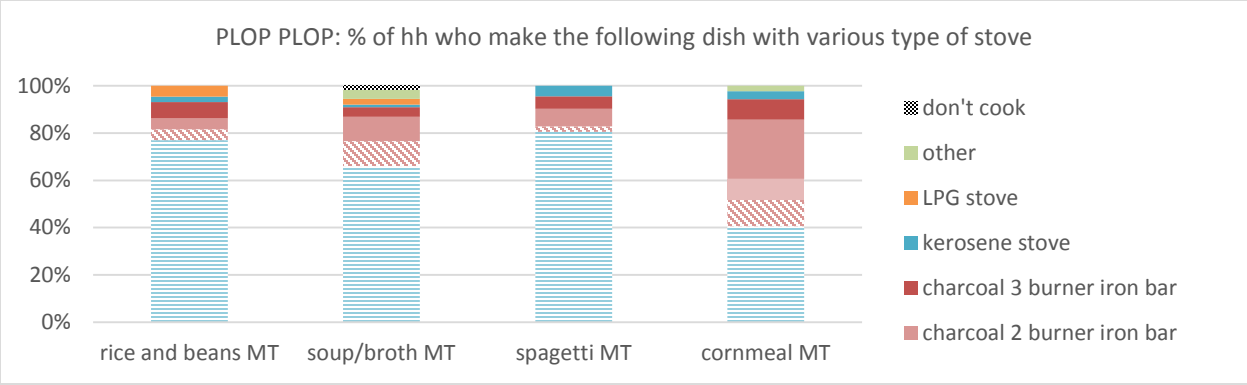


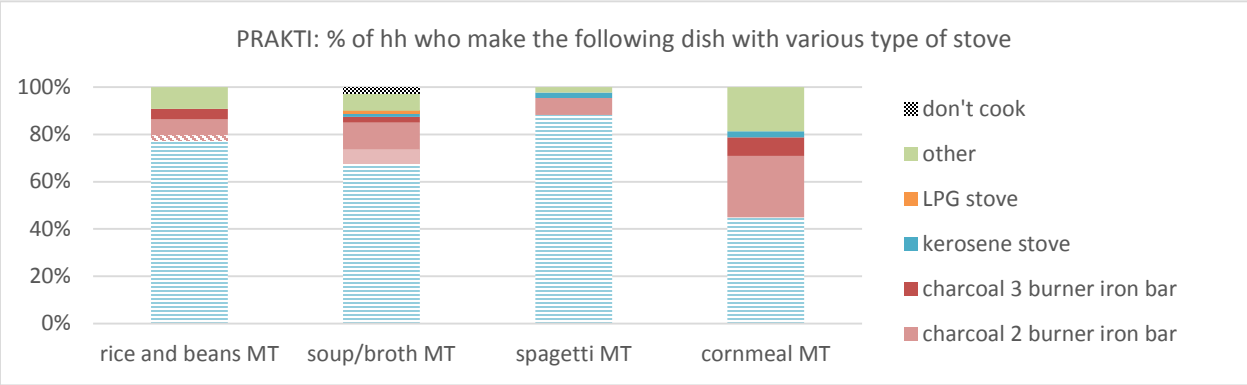



ECO RECHO: % of hh who make the following dish with various type of stove
100%
80%
60%
40%
20%
0%
rice and beans MT
soup/broth MT
spagetti MT
cornmeal MT
don't cook
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar


ECLAIR: % of hh who make the following dish with various type of stove
100%
80%
60%
40%
20%
0%
rice and beans MT
soup/broth MT
spagetti MT
cornmeal MT
don't cook
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

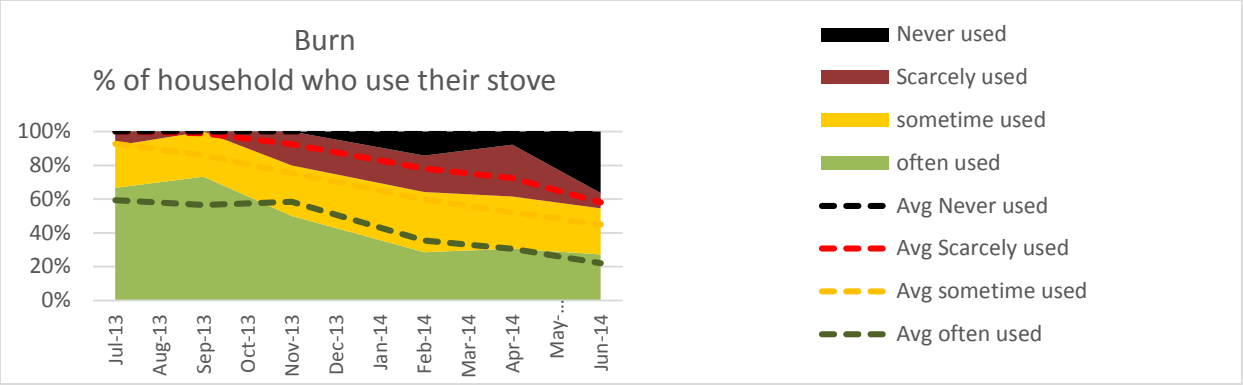

MEN RECHO: % of hh who make the following dish with various type of stove
100%
80%
60%
40%
20%
0%
rice and beans MT
soup/broth MT
spagetti MT
cornmeal MT
don't cook
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

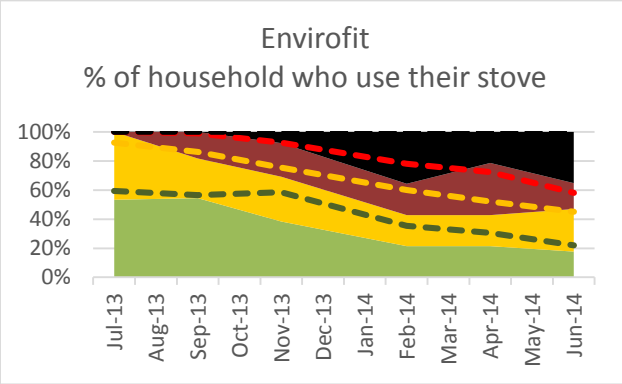

PLOP PLOP: % of hh who make the following dish with various type of stove
100%
80%
60%
40%
20%
0%
rice and beans MT
soup/broth MT
spagetti MT
cornmeal MT
don't cook
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

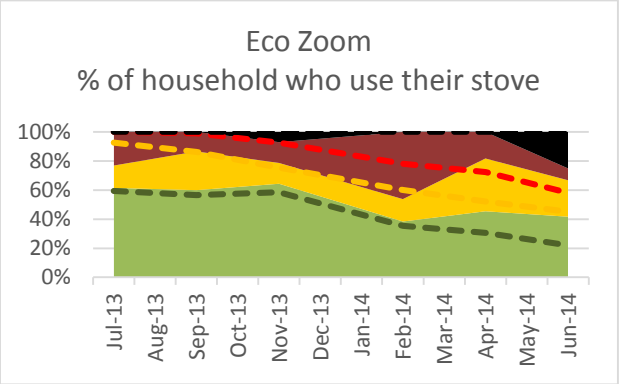

PRAKTI: % of hh who make the following dish with various type of stove
100%
80%
60%
40%
20%
0%
rice and beans MT
soup/broth MT
spagetti MT
cornmeal MT
don't cook
other
LPG stove
kerosene stove
charcoal 3 burner iron bar
charcoal 2 burner iron bar

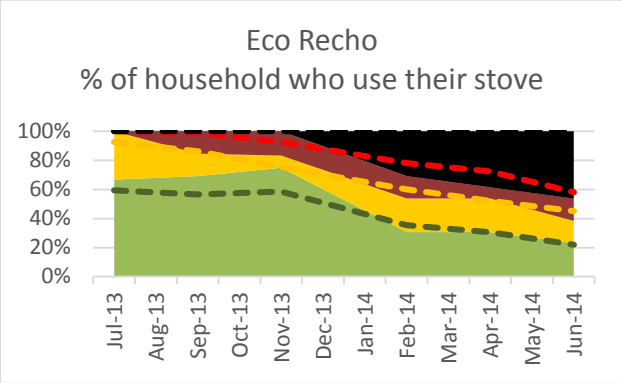
ANNEX III: DETAILS REGARDING STOVE USAGE

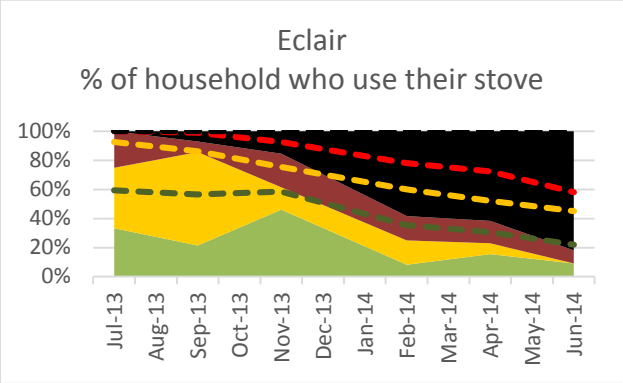
This annex provide details on the usage rate measured by the SUMS.

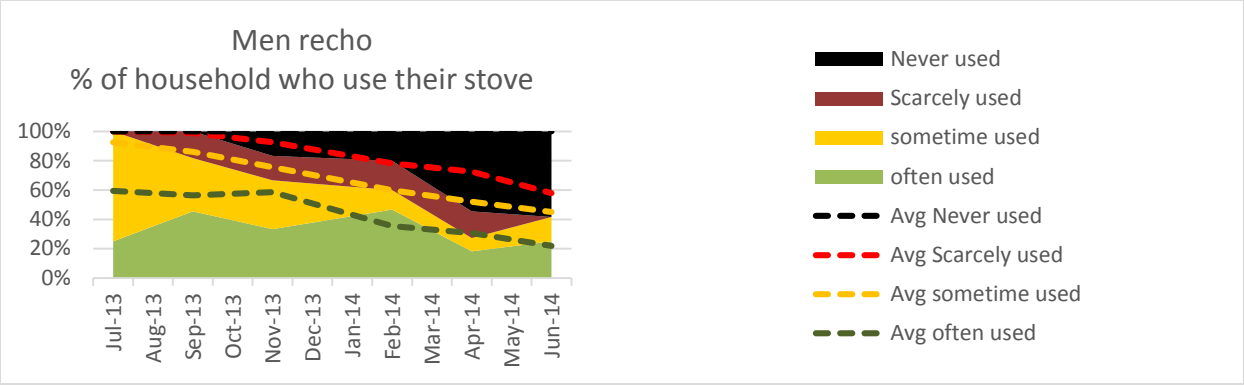


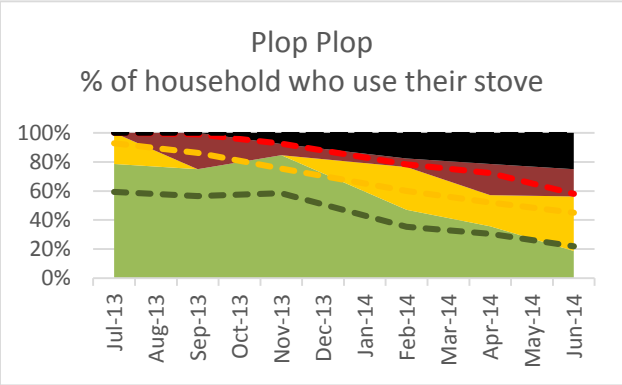


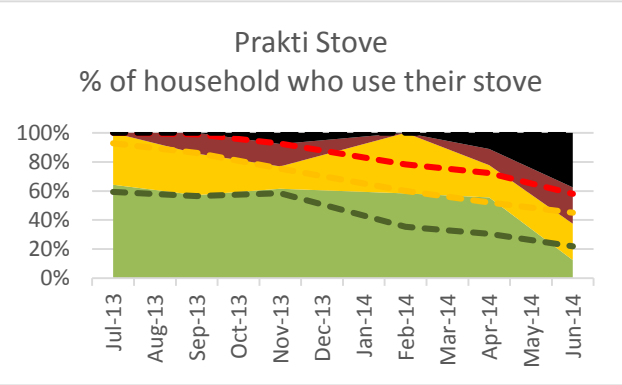




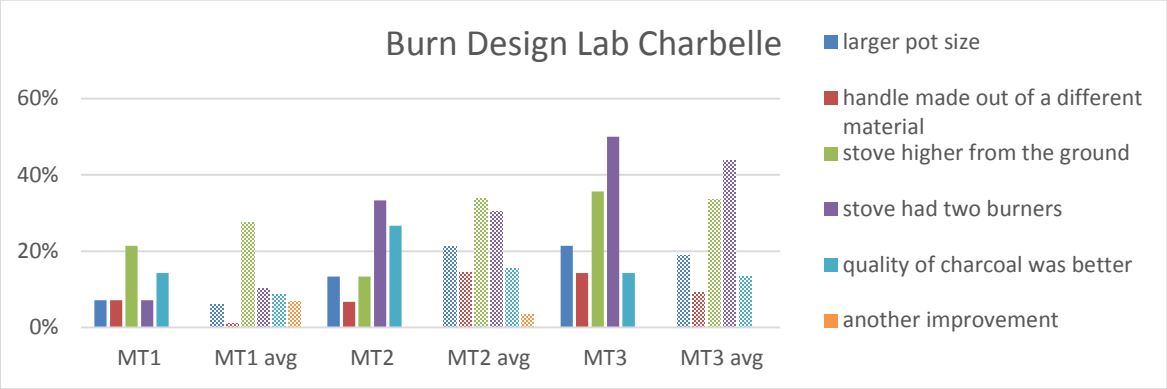


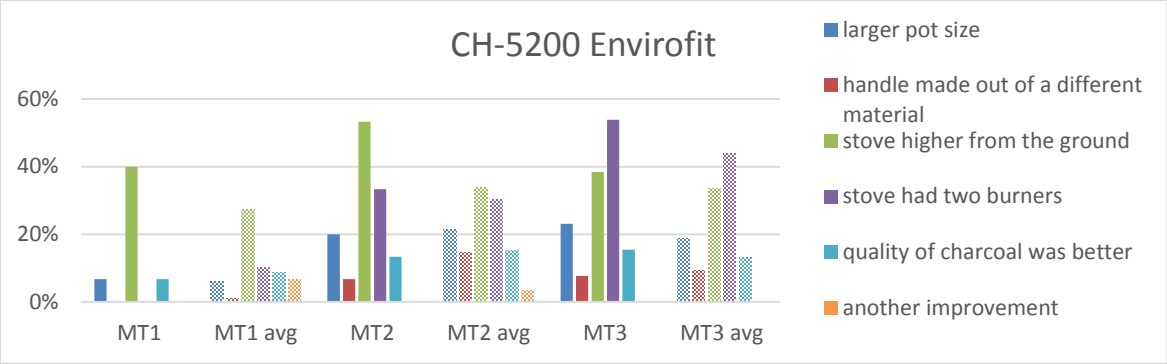

Men recho
% of household who use their stove
100%
80%
60%
40%
20%
0%
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Never used
Scarcely used
sometime used
often used
Avg Never used
Avg Scarcely used
Avg sometime used
Avg often used

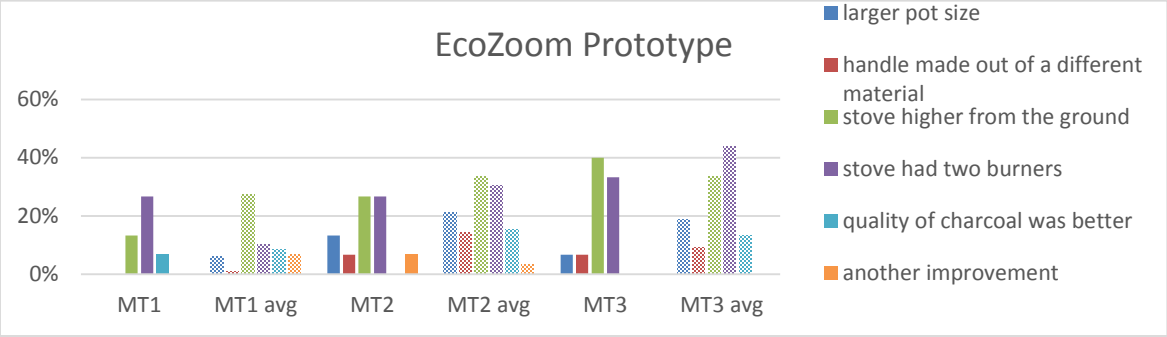

Plop Plop
% of household who use their stove
100%
80%
60%
40%
20%
0%
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14

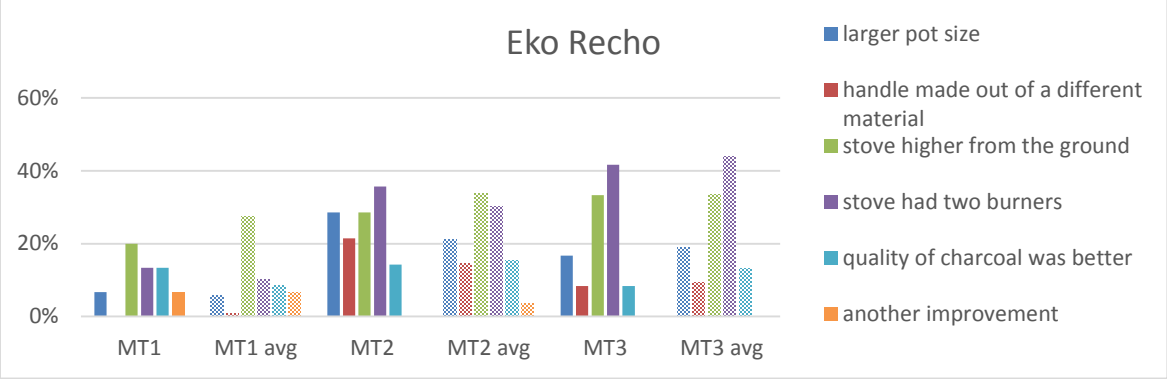

Prakti Stove
% of household who use their stove
100%
80%
60%
40%
20%
0%
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14

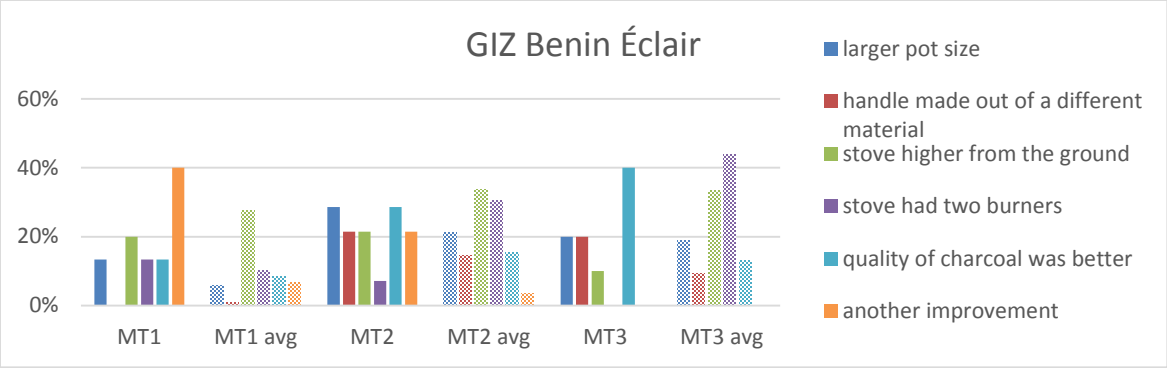
ANNEX IV: DETAILS REGARDING IMPROVEMENTS RECOMMENDED BY USERS

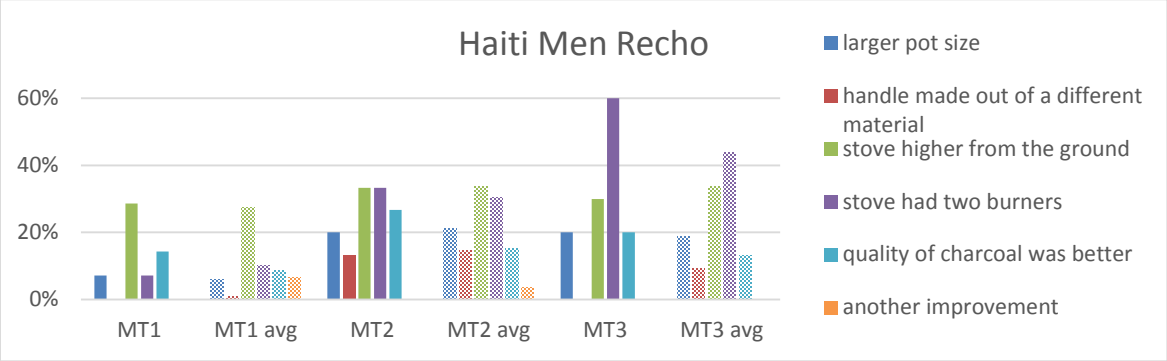


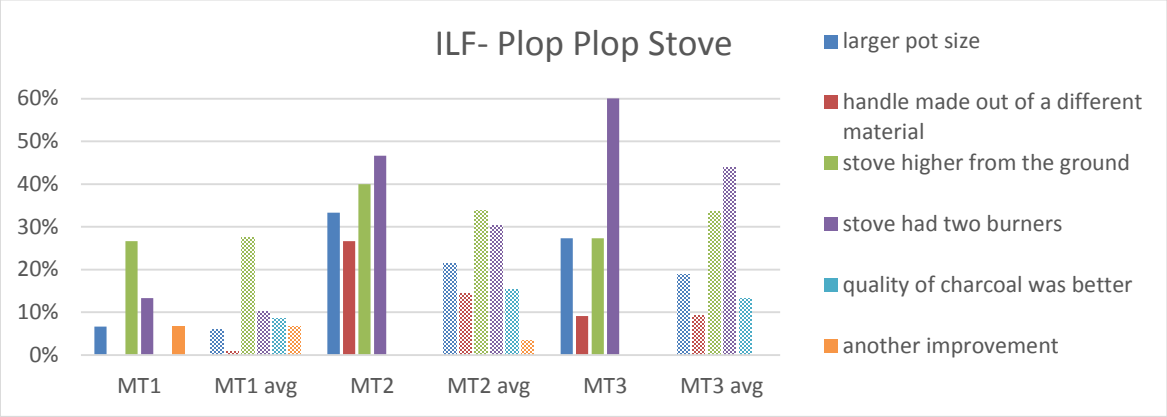


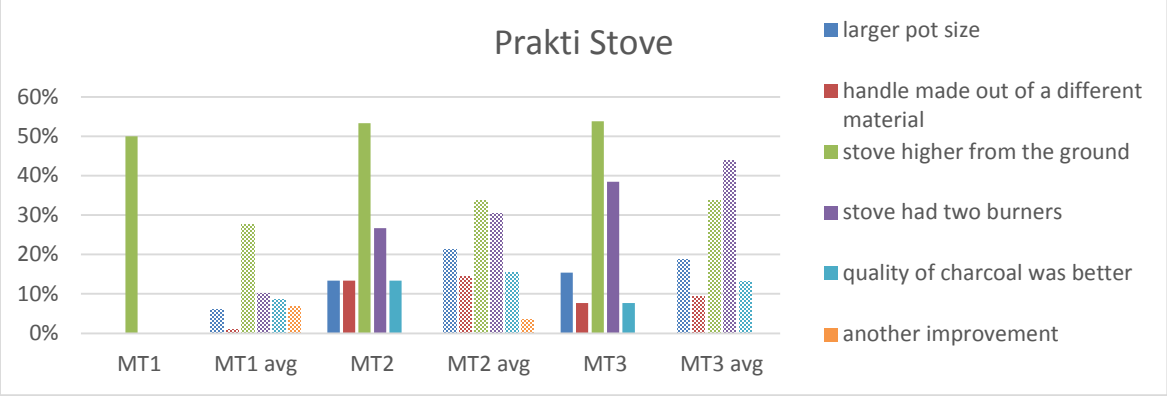




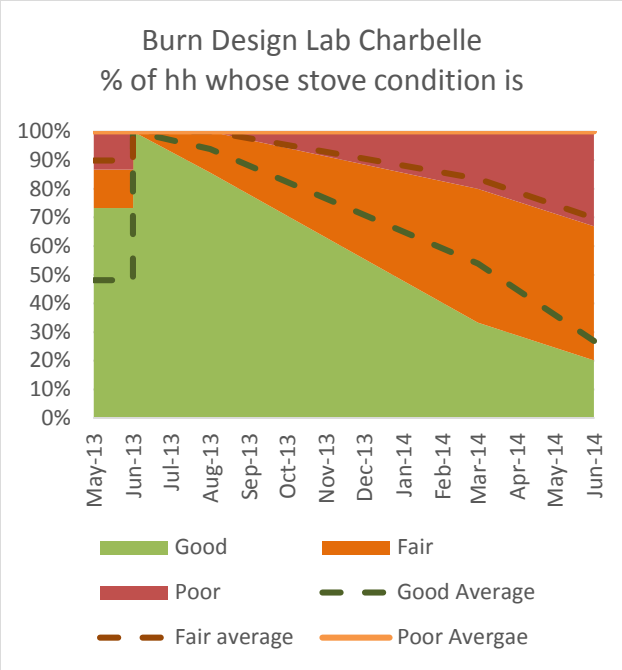

GIZ Benin Éclair
60%
40%
20%
0%
MT1
MT1 avg
MT2
MT2 avg
MT3
MT3 avg
larger pot size
handle made out of a different material
stove higher from the ground
stove had two burners
quality of charcoal was better
another improvement

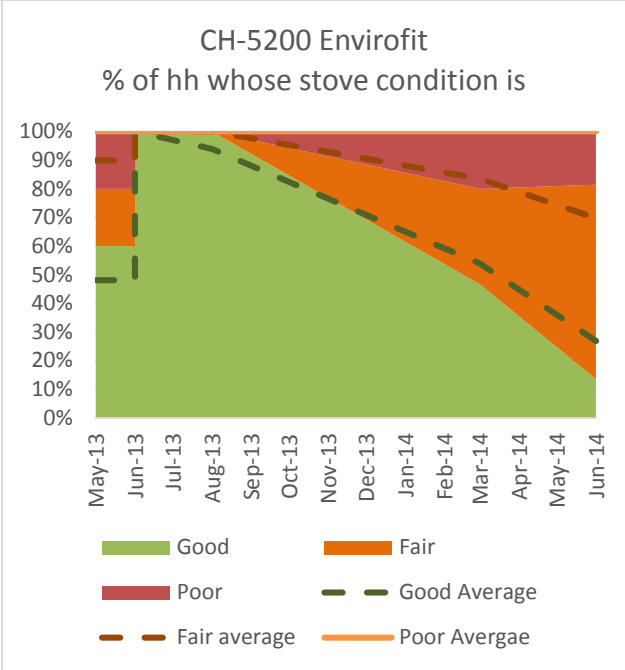

Haiti Men Recho
60%
40%
20%
0%
MT1
MT1 avg
MT2
MT2 avg
MT3
MT3 avg
larger pot size
handle made out of a different material
stove higher from the ground
stove had two burners
quality of charcoal was better
another improvement

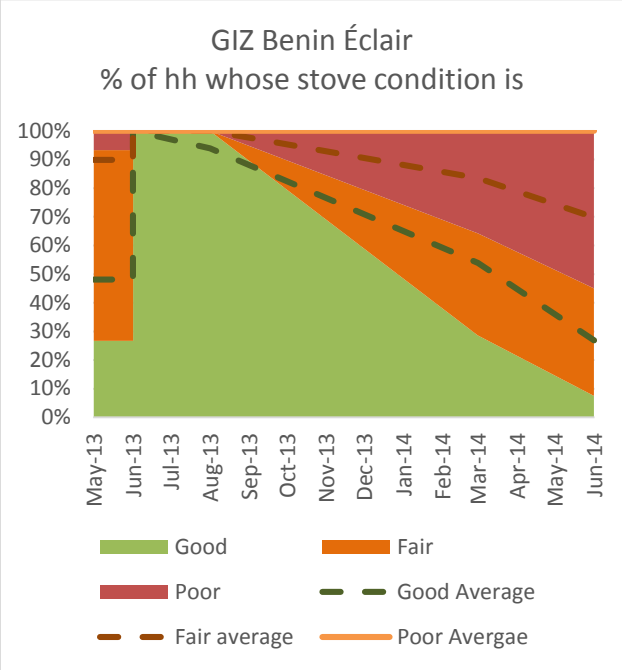

ILF- Plop Plop Stove
60%
50%
40%
30%
20%
10%
0%
MT1
MT1 avg
MT2
MT2 avg
MT3
MT3 avg
larger pot size
handle made out of a different material
stove higher from the ground
stove had two burners
quality of charcoal was better
another improvement

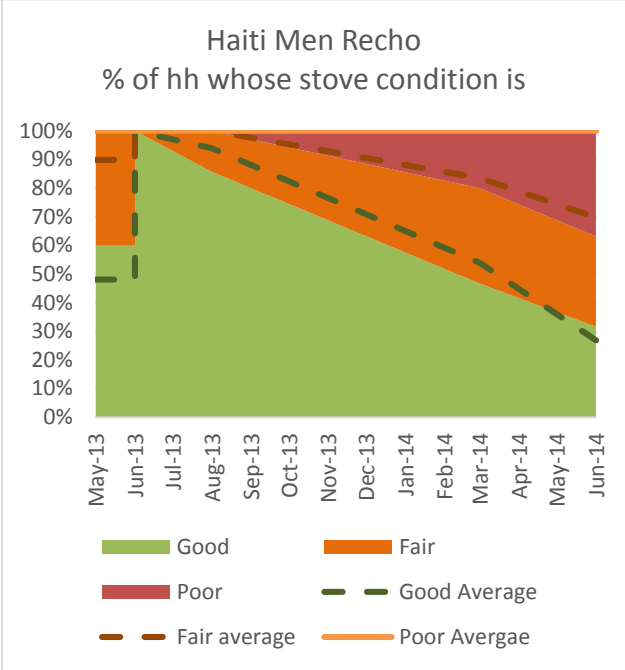

Prakti Stove
60%
50%
40%
30%
20%
10%
0%
MT1
MT1 avg
MT2
MT2 avg
MT3
MT3 avg
larger pot size
handle made out of a different material
stove higher from the ground
stove had two burners
quality of charcoal was better
another improvement

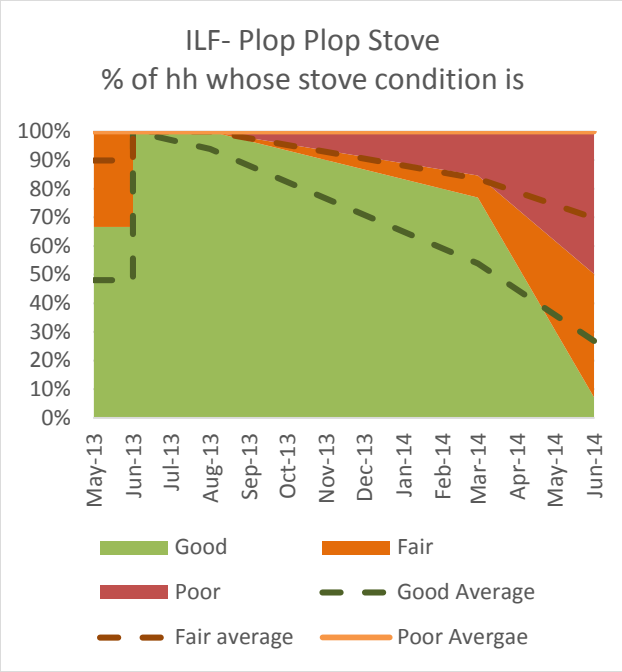
ANNEX V: DETAILS REGARDING OVERALL STOVE CONDITION

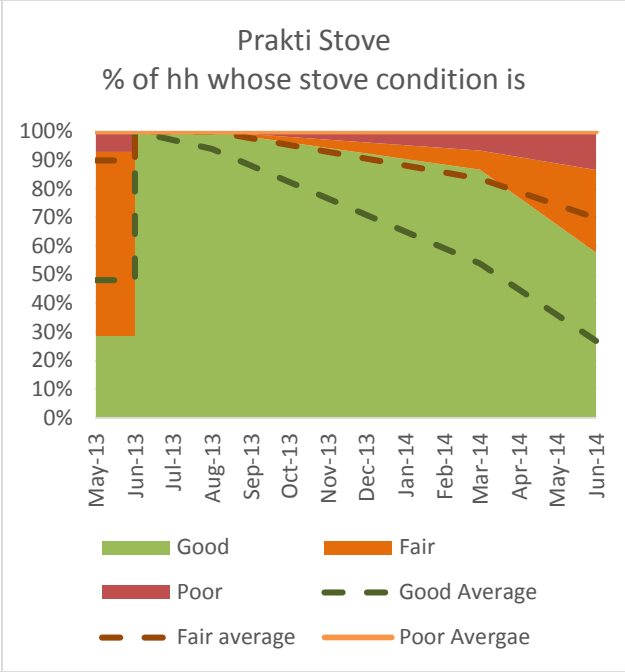


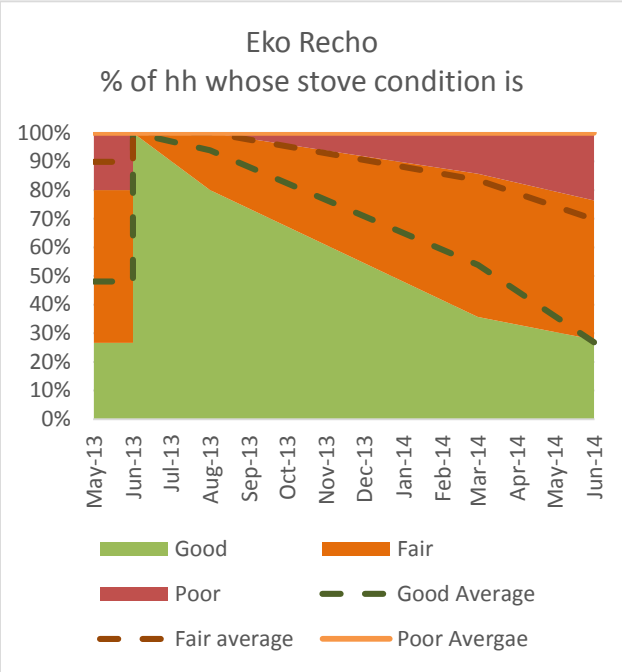


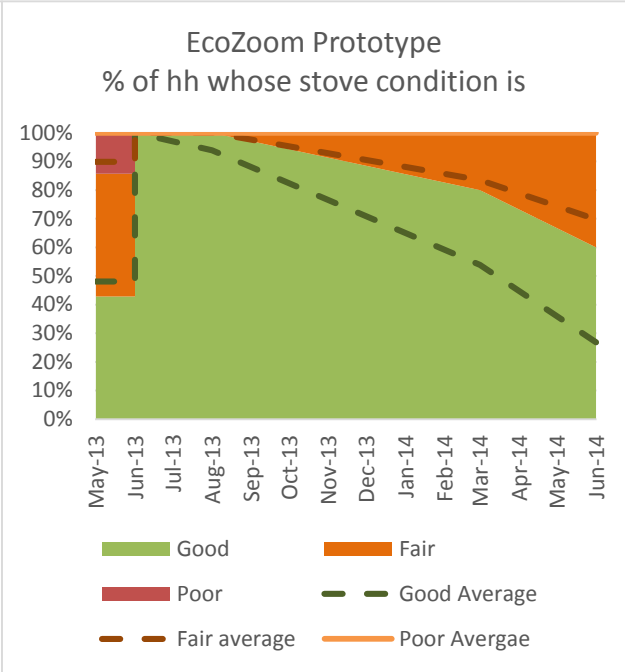




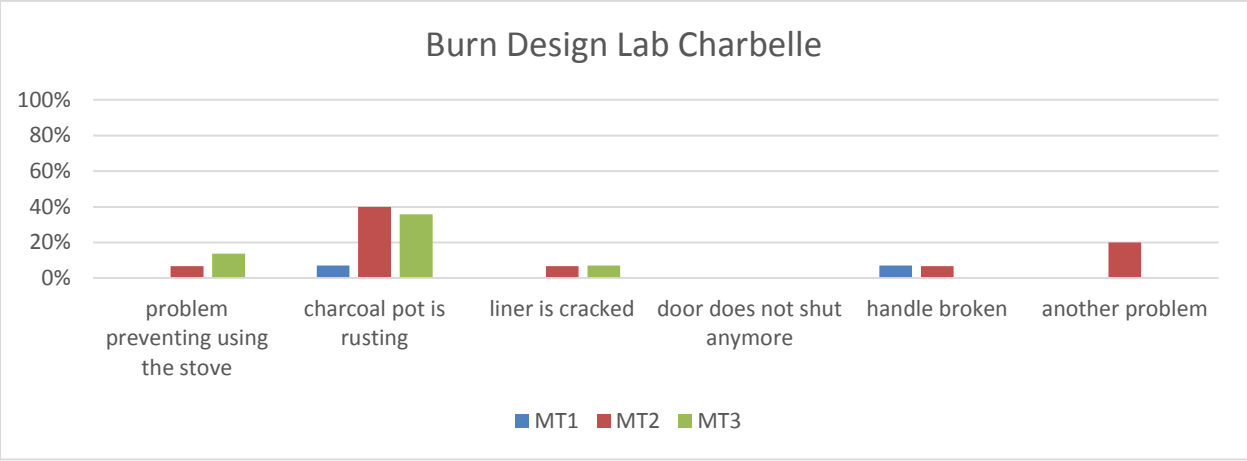

ILF- Plop Plop Stove
% of hh whose stove condition is
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Good
Fair
Poor
Good Average
Fair average
Poor Avergae

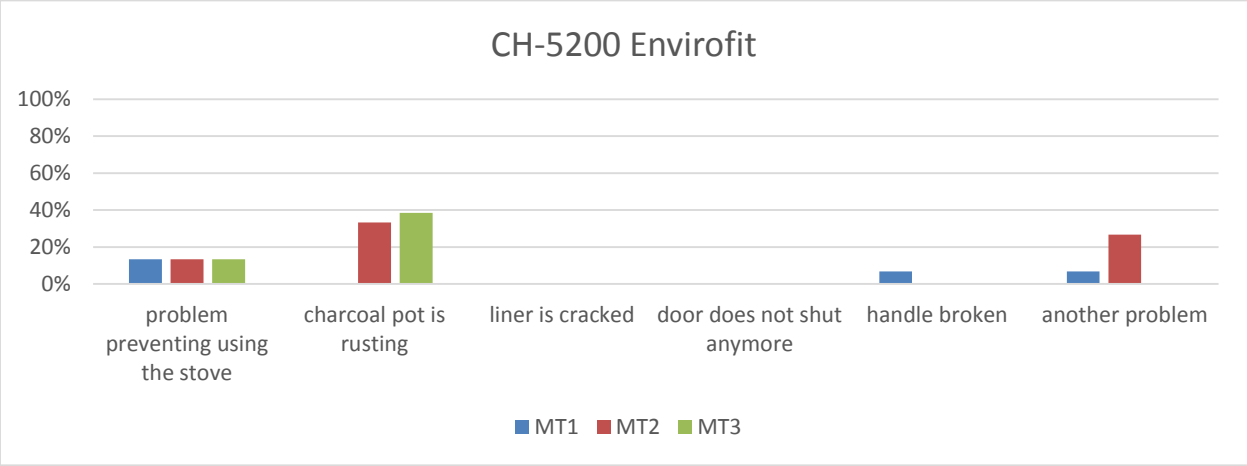

Prakti Stove
% of hh whose stove condition is
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Good
Fair
Poor
Good Average
Fair average
Poor Avergae

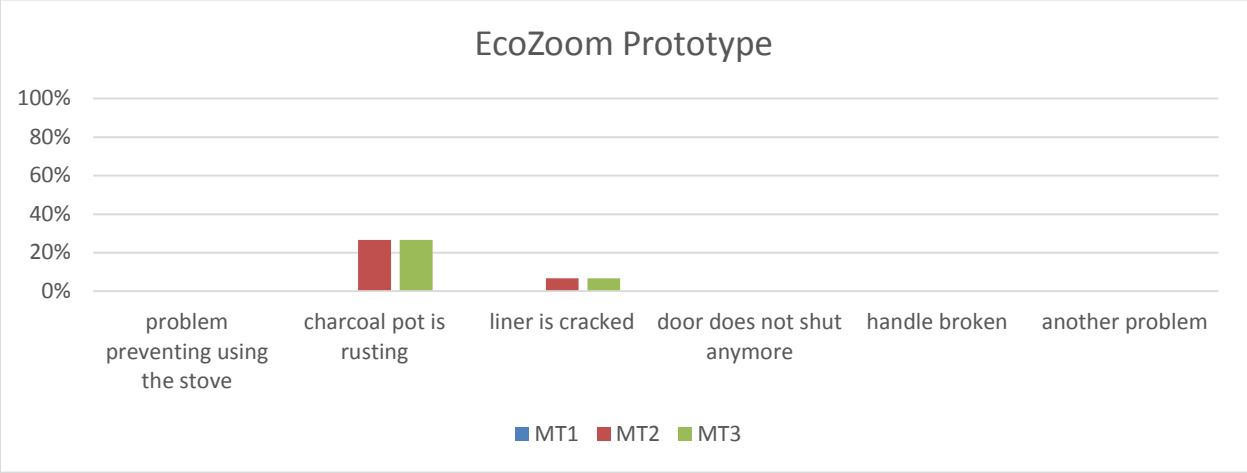

Eko Recho
% of hh whose stove condition is
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Good
Fair
Poor
Good Average
Fair average
Poor Avergae

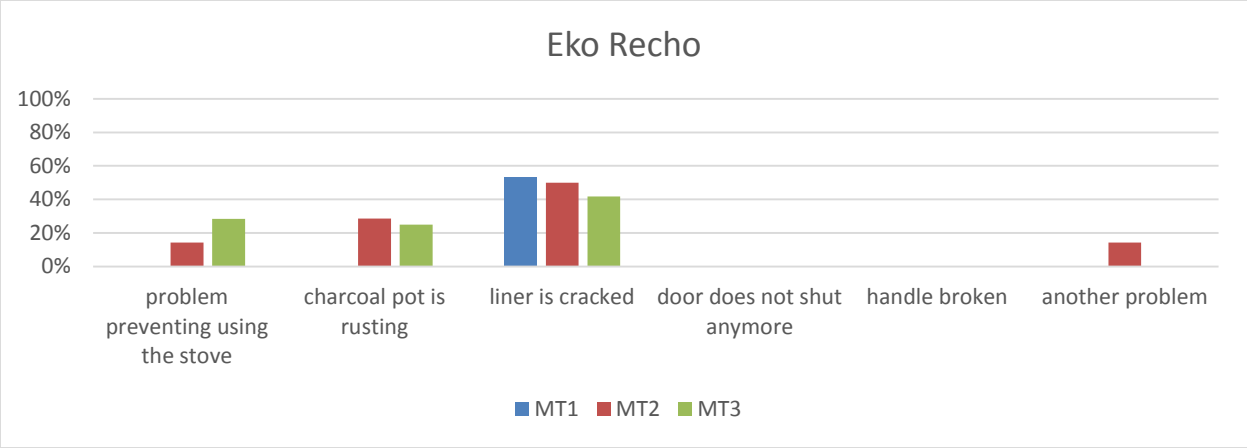

EcoZoom Prototype
% of hh whose stove condition is
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
May-13
Jun-13
Jul-13
Aug-13
Sep-13
Oct-13
Nov-13
Dec-13
Jan-14
Feb-14
Mar-14
Apr-14
May-14
Jun-14
Good
Fair
Poor
Good Average
Fair average
Poor Avergae

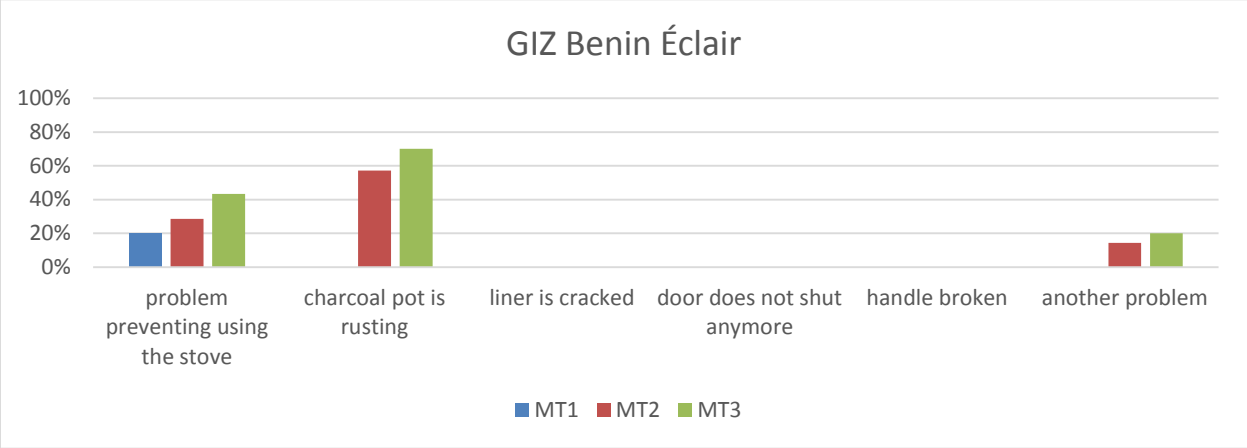
ANNEX VI: DETAILS REGARDING STOVE PARTS DAMAGED

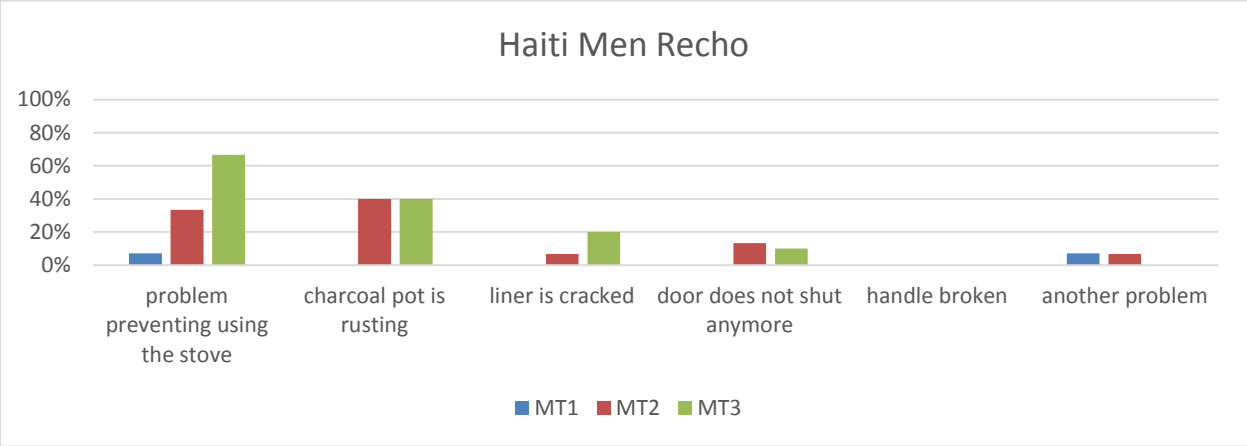


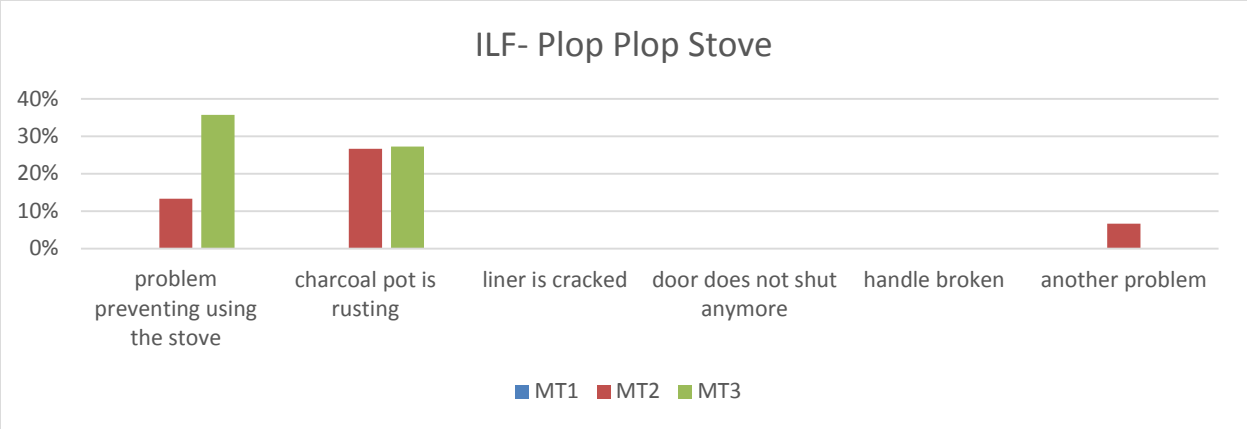


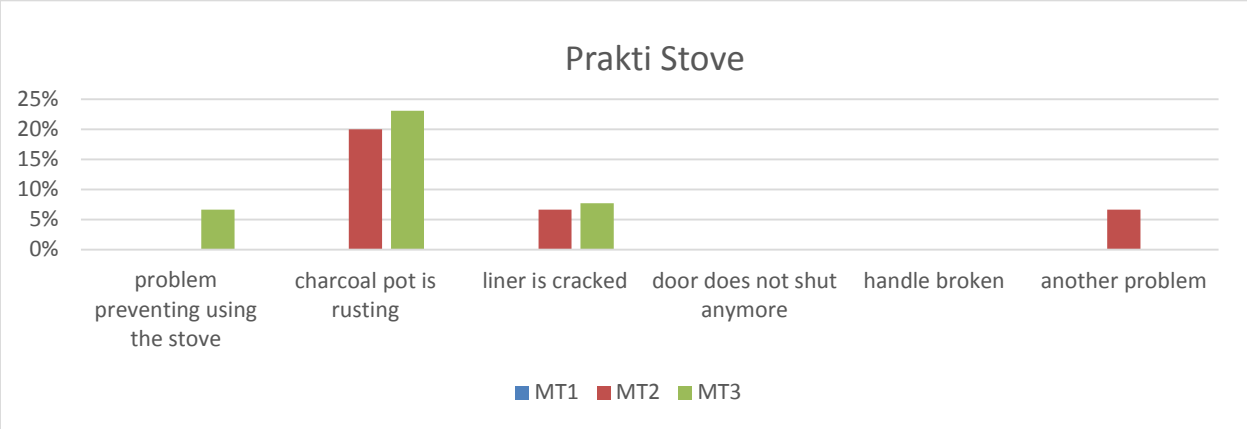


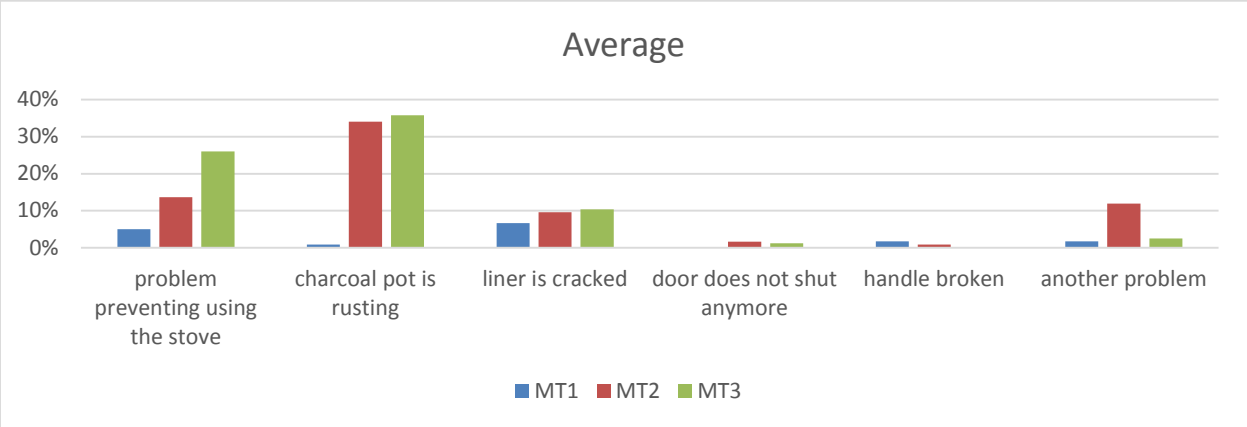

Eko Recho
100%
80%
60%
40%
20%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3


GIZ Benin Éclair
100%
80%
60%
40%
20%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3


Haiti Men Recho
100%
80%
60%
40%
20%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3


ILF- Plop Plop Stove
40%
30%
20%
10%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3


Prakti Stove
25%
20%
15%
10%
5%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3


Average
40%
30%
20%
10%
0%
problem preventing using the stove
charcoal pot is rusting
liner is cracked
door does not shut anymore
handle broken
another problem
MT1
MT2
MT3

ANNEX VII: STOVES CONDITIONS AT THE END OF THE STUDY

a. Burn Design

b. CH 5200 Envirofit

c. EcoZoom Prototype

d. EcoRecho

e. Éclair

f. Men Recho

g. Plop Plop

h. Prakti Wouj