AFRICA ENERGY SERVICES GROUP LTD

AESG **Rwanda**

TOWARDS AN IMPROVED COOK STOVES PROGRAM:

Market Based Solutions to Eliminate Energy Poverty

Enquiry on the use of improved cooking stoves in Bugesera, Kirehe and Ngororero Districts

Draft Report

Submitted to SNV Rwanda

By

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EXECUTIVE SUMMARY

Majority of the rural households in Rwanda regularly use firewood for cooking purposes. Conservative sources indicate the level of penetration of improved efficient woodstoves for the rural households to be around 5%. With the large rural population there is great potential for ICS upscale.

Work on ICS dates back to the late 1980s when the government through NGOs engaged the rural population in developing an ICS. Initial assessment majorly looked at fuel efficiency and indoor air pollution. Since then, more work has been done by other institutions such as practical Action, CARE and GIZ.

Rwanda has the needed infrastructure in place for production of stoves with a very poor distribution network as evidenced by the many players some of whom have been highlighted in this report. Despite the long history ICS have in the country, there are still some chronic market challenges hindering wider upscale. Some of these challenges include access to capital by the entire ICS market chain. The sector is also disorganised and with no agreed quality standard which has brought about unfair competition amongst the players. The report aims at identifying the bottlenecks in the Canarumwe/Tekavuba ICS value chain and recommending appropriate measures to mitigate them.

SUMMARY OF FINDINGS

1. There is a positive appreciation of the C+T cook stoves.

2. Stove efficiency testing classified C/T as the best stove among those sampled in the households that has reliable fuel wood saving capacity

3. The kitchen environment showed poor smoke evacuation among C/T users and non-users; there is therefore a need for incorporating a chimney in C/T installations or at least provide other smoke evacuation measures

4. A gasifying stove was tested, however, the testing was conducted separately since it is yet to be disseminated in the households. It demonstrated high efficiency in fuel wood use and produces carbonized charcoal at a high conversion rate of 17%; the carbonized charcoal can be used for further burning. However, at a cost of about RWF 10,000, the gasifying stove may seem relatively costly to many potential rural users.

5. The penetration and adoption of C/T stove is still low.

6. Some observations along the product supply chain have indicated that some stove producers (Cooperatives) are yet to receive outstanding payments for stoves supplied. This was mainly due to improper transaction where by the stoves were supplied without any official binding contract.

7. The C/T stove value chain actors are not at the same level of active participation to sustain the C/T value chain, only 2/3 of producer Cooperatives in the three target Districts were found active.

8. The value chain for Tlud does not exist currently, mainly because it is new a product on the market that requires extra effort in product promotion and marketing. Only production center of Tlud is active. The initial sales showed good supply of stoves, but there is need to establish a network of retailers in order to ensure a growing and sustainable market development for sustainability.

9. Given the comparatively high price of Tlud stoves, it is only logical to target first the middle income levels before introducing it into rural areas, unless a subsidy mechanism is introduced. Tlud stove users stated that they were able to save 60 to 70% of the cost on wood fuel.

10. Once the adoptability is proven, the local Government could be solicited to participate through initial direct and indirect subsidy schemes in order not only to help the users on health grounds, but also on the basis of environmental benefits.

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Abbreviations and acronyms

Abbreviation	**In full**
AESG	Africa Energy Services Group
BEST	Biomass Energy Strategy
CCT	Controlled Cooking Test
CDM	Clean Development Mechanism
C/T	Canarumwe/ Tekavuba Stoves
DGF	Directorate General of Forests
EWSA	Energy, Water and Sanitation Authority
GIZ	German International Cooperation
GoR	Government of Rwanda
GVEP	Global Village Energy Partnership
GHG	Green House Gas
ICS	Improved Cook Stoves
LPG	Liquefied Petroleum Gas
MFI	Micro Finance Institutions
MININFRA	Ministry of Infrastructure
PAC	Practical Action Consulting
PU	Production Unit (Cooperative of Canarumwe/Tekavauba stove producers)
RBESS	Rwanda Biomass Energy and Stoves Survey
RURA	Rwanda Utilities Regulatory Agency

SACCO	Savings and Credit Coperative Society
SNV	Netherlands Development Agency
TLUD	Top Lit Up-Drift Gasified Stove
WBT	Water Boiling Test

1.0 INTRODUCTION

Improved Cook Stove (ICS) program was started in Rwanda like in other East African countries in the late eighties. Since then there has been a penetration of 'improved' stoves of over 50% by 2009. The aim of the program was to combat forest degradation as a result of population growth and the fact that a large majority of the population did not have access to modern energy services and relied on charcoal and firewood for their daily cooking energy needs. Even as of today, most of the low income households still use traditional three stone stoves, with improved income, households tend to switch to improved cookstoves (ICS) which are more efficient. However, the quality of these stoves varies greatly; often the improvement versus traditional methods is limited in performance. The main challenge for any cookstove program in Rwanda will be affordability of stoves and fuels. SNV thus has been invited by GoR /EWSA to develop an intervention in testing the market based approach for ICS sector development.

The target Districts of this study were part of a recent ICS program executed by EWSA in collaboration with Practical Action Consultancy. The program introduced in 2011 the production and distribution of a new improved charcoal stove – the Canarumwe ivuguruye- for mainly urban customers and two ICS firewood stove models the Canaruwe and Tekavuaba ceramic liners destined to be integrated in a mud hearth as fixed firewood stove. Concerning these firewood stoves, potter cooperatives have been organized and equipped in 15 Districts over the country. In the target area of this study, 4 production cooperatives were part of the inquiry concerning their economic viability: one in Ngororero, two in Bugesera and on again in Kirehe Districts.

These production units in the target area just as several others over the country show today serious difficulties to continue their business after certain project inputs have ended.

In May 2012, SNV Rwanda conducted a pilot study on: "Sustainable ICS dissemination and biomass supply in rural Rwanda". The study covered the Districts of the Kirehe and Bugesera in the Eastern Province as well as some neighboring Districts (Kamonyi, Rulindo and Muhanga) on the functioning of the Canarumwe/Tekavuba(C+T) stove production units (cooperatives) and on consumer perceptions. The study confirmed the capacity of the local production units to produce good quality stoves. It revealed however that further market development is a critical issue, as the production units have not yet been able to switch from the ensured 'project' market to engaging the wider market in the districts essentially for lacking a retailing system. As a consequence, C+T stoves

The current study was conceived to address this problem by deepening the knowledge about:

- The appreciation of stoves by their actual users and in the case of a positive outcome, measures to increase further demand;

- The viability of the Producer Cooperatives of C+T stoves in the target Districts as an profitable enterprise and measures to increase their performance
- The views of existing and potential retailers and their expectations by integrating C+T stoves in their assortment as well as their role in promotion andtraining needs;
- The type and amount of work C+T installers do (integrating the ceramic liners into build up mud hearths); their role in promotion and training needs;

Linked to the mentioned inquiry interest is the question –very important for SNV's future intervention options- if it is worth to invest in the promotion of the Canarumwe and Tekavuba stoves as they are a relatively 'classical' answer to the challenges of efficient firewood stoves.

New technological solutions are in sight, in particular the application of the gasifying principles to household stoves allowing for new horizons of efficiency, cleanness and cooking comfort. It was therefore equally important to undertake a series of tests in order to compare the technical performance (fuel and thermal efficiency) of stoves actually found in the sample households and to put them in perspective with the performance of a very recently, locally produced TLUD gasifier, the Karundura stove (not yet present in the households).

2.0 APPROACH AND METHODOLOGY

2.1 Inquiry tools

5 different questionnaires have been designed to respond to the research objectives. These are:

Table 1: Inquiry tools

Category of Respondents	Questionnaire applied	Thematic areas covered
Households C+T stove users	User questionnaire target group	Socio-economic profile; stove use; stove appreciation etc.
Households non users of C+T	User questionnaire control group	Socio-economic profile; stove use; stove appreciation etc.
Cooking related observations	User group	Kitchen environment, fuel wood used, type of stoves etc.
Cook stove producers	Producer group	Socio-economic profile; production method; production costs and revenues etc.
Cook stove retailers	Stove Retailers	Socio-economic profile; retailing costs and returns etc.
Cook stove installers	Stove installers	Socio-economic profile; retailing costs and returns etc.

All questionnaires have been field tested and fine-tuned before being administered by 9 trained enumerators monitored by 3 supervisors divided in groups of 4 persons for each District.

2.2 Data Collection

Sampling overview of target groups

Of all the respondents, Kirehe accounted for 36%, Bugesera for 34% and Ngororero for 30% of both total target and control group of users interviewed.

Table 2: Categories and # of respondents

Respondents	Bugesera	Ngororero	Kirehe	Total
Stove producers	24	9	19	**52**
Cook stove users C+T*	47	41	39	**127**
Non users of C+T*	33	29	44	**106**
Installers(individuals)	14	15	9	**38**
Total	**118**	**94**	**111**	**323**

*Canarumwe and Tekavuba stoves

Table 2 shows categories and numbers of reached respondents. It has to be said however that the two household (HH) categories interviewed were in the same time subject of direct household observations, the whole constituting a group of 233 HHs. The category 'Installers are falling together with stove producers. The majority of them were in producer groups when the groups were large, then they acquired that skill of installing C+T, while others are casual masons who practice construction of the houses locally . Independent retailers are a very tiny group, in fact from the 15 people indicated; only 1 is an independent retailer. 14 of them are simply producers selling their stoves in the vicinity of the production unit.

2.3 Sampling method and selection of respondents

Overview

To explore and identify sample HHs using the C+T stoves and HH using other stoves, the survey was designed to cover 3 districts namely Bugesera, Kirehe and Ngororero, a stratified**,** multi-stage, area probability sampling was applied. The objective of the design was to give every sample element (i.e. HHs of C+T users and non-users) an equal and known chance of being chosen for inclusion in the sample. This was achieved by:

(a) Strictly applying random selection methods at every stage of the sampling;

(b) Applying sampling with probability proportionate to population size and income level wherever possible.

Against this background the HH sample was **stratified** by key characteristics of the population based on an area sampling comprising the administrative units of the country in a decreasing hierarchical arrangement of District, Sector and Cell. Wherever possible within the strata, random sampling was

conducted with probability proportionate to the population in a certain income level. The purpose was to guarantee that an income group with a larger number had proportionally greater probability of being chosen into the sample and different income levels are reflected in the sample. As proposed in the TOR the "Ubudehe" poverty classification used by the Administration was used. The classification contains the following categories:

- ***Umutindinyakujya***(those in absolute poverty) who may or may not be using an ICS.
- ***Umutindi***(the very poor), ***Umukene***(the poor),
- ***Umukenewifashije***(the resourceful poor)
- ***Umukungu***(the food rich),
- ***Umukire***(the money rich).

This allows for understanding whether income levels might have influence on the possession of an ICS or the choice of a specific ICS.

Field preparation: Contact with local authorities

The local authorities from district to sector level downwards were contacted and their facilitation in this research requested. A letter from each target District was given to facilitate enumerators their fieldwork in all Sector of the concerned District. The local authorities were very much welcoming and facilitated enumerators to reach their focus.

Interviews and direct observation

Enumerators visited a randomly chosen sample of households (following the approach prescribed above) in each Sector where they introduced themselves mentioning the objective of the research and requested humbly the time and willingness of the respondent go together through the questionnaire. After going through it, enumerators made direct observation on current condition of the kitchen, stoves in use and how biomass fuel is handled. C+T Producers as well as local authorities served as key informants in identification of C+T installers and retailers. These were interviewed where they were met and mostly in their homestead or at their place of work. The interview session ended by thanksgiving for the valuable contribution of the respondent on the study and the payment of 1000 RWF as a 'symbolic' remuneration for the time spent on this task.

2.3 Data Analysis

For the data analysis, SPSS software was used using the following steps;

a) Data processing

This step deals with processing the questionnaire responses into output. The tasks involving data processing includes: coding, data capture, editing, dealing with invalid or missing data and where necessary, creating derived variables. The aim in this step is to produce data that would be as free from errors as possible.

b) Quality control

These tasks include: interviewer training, data editing, computer program testing, follow-up of non-respondents, and spot-checks of collected responses and output data.

c) Analysis of results

i) Organizing the data using frequency distribution tables

ii) Displaying the data through different graph types to provide –visual results

2.4 Stove Testing

Two kinds of testing were conducted namely: Water Boiling Test (WBT) and the Controlled Cooking Test (CCT). The WBTprovides reliable information about the performance of wood burning stove models. The test consists of three phases that determine the stove's ability to: bring water to a boil from a cold start; bring water to a boil when the stove is hot; and, maintain the water boiling at simmering temperatures. It has been used in its standardized format to evaluate a series of stoves which had been found in the sample households.

Controlled Cooking Test (CCT)

The CCT was done for cooking of Beans, Rice and Potatoes. It is a field test that measures stove performance and allows for comparing stoves as used locally. The CCT is designed to assess stove performance in a controlled setting using local fuels, pots, and food. It reveals how stoves perform under ideal conditions but not necessarily what is actually achieved by households during daily use. Comparing different stoves performance' needs testing under the same cooking conditions (height, ambient temperature) as well as the same fuel, pot and food for cooking.

Types of stoves tested

The following stoves used by the sample households were tested for WBT and CCT: Canarumwe, Tekavuba, Rondereza / Darfur stove, Gisafuriya, Kibotte and 3 stones open fire. The results of the CCT as presented in this report are those obtained by cooking beans of the same batch and provenience.

In addition, new stoves coming up but which had not been found in the sample households, have been tested in comparison: Ezy stove, Eco Zoom,(imported Rocket stoves) and a newly produced TLUD Gasifier, the Karundura produced by a Rwandan stove factory.

3.0 Presentation of inquiry Results

3.1 Stove users

Questionnaires were administered to randomly selected households of C+T users and non-users to gather information about their socio-economic status, fuel and stove preference, cooking habits among other aspects. Direct observations were used for additionally assesing the kitchen environment, stoves in use, fuel handling and the general cooking conditions.

3.1.1 Socio-economic profile of stove users (target and control group)

Table 3: Marital status of respondents

Matrimonial status	Target	%	Control	%	Total	%
Single	17	14%	8	7%	**25**	**11%**
Married	83	69%	81	72%	**164**	**70%**
Divorced	6	5%	4	4%	**10**	**4%**
Widow/er	15	12%	19	17%	**34**	**15%**
Total	**121**	**100%**	**112**	**100%**	**233**	**100%**

The respondents were mainly (70%) married partners in both target and control group. The table above is showing their matrimonial category. Window/er(s) were 15%, singles were found at 11%, and divorced at 4% only.

Features of sample household respondents

58 % of household have a telephone as means of communication. 76% of respondents were female 24% were male. The average age of respondents was 43. 69% of respondents were married, 18% widows, 8% singles and 5% divorcees. The average household size is 5 persons, and average age was 44 years.

Households with children under 5 years

The survey confirms that among C+T owners and non C+ T users 99% in each case had children aged 3 years or less. This indicates that measures of smoke avoidance and evacuation have a great importance given the particular vulnerability of young children to indoor air pollution from solid biomass cooking.

Table 4: Household with children of 0 to 5 years

Children of 0-5 years	Target	%	Control	%	Total	%	Cumulative
0	28	30%	59	49%	**87**	**41%**	41%
1	32	35%	45	37%	**77**	**36%**	77%
2	21	23%	16	13%	**37**	**17%**	94%

3	10	11%	0	0%	**10**	**5%**	99%
4	0	0%	1	1%	**1**	**0%**	100%
5	1	1%	0	0%	**1**	**0%**	100%
Total	**121**	**100%**	**112**	**100%**	**233**	**100%**	

89% C+T stove users confirmed that the use of these stoves reduced the problem of respiratory diseases and eye illnesses but still, appropriate smoke evacuation measures and/or chimneys are rare. There is therefore need of training installers of C+T stoves in order to propose appropriate measures for a cleaner kitchen and cooking environment.

Education status

30% of head of households of the target group and 31% in the control group never attended schools and are illiterate. 60% in the target and 50% in the control group had primary school level. This portrays the low level of formal education among the rural population where 90% of target and to 81% of control didn't have secondary level of education.

Table 5: Level of education of head of household

Level of education	Target	%	Control	%	Total	%
None	36	30%	35	31%	**71**	**30%**
Primary	73	60%	56	50%	**129**	**55%**
Secondary	11	9%	13	12%	**24**	**10%**
Vocational	1	1%	2	2%	**3**	**1%**
University	0	0%	3	3%	**3**	**1%**
Total	**121**	**100%**	**112**	**100%**	**233**	**100%**

Household income and expenditures

The target group belongs for a majority of 88% to the categories of very poor to poor people and were others belong to the medium category mainly. There is a difference in target group and control group which has 50% belonging to poor and very poor at 45% and 5% respectively. For the control group, the corresponding figures of the poor people account for 50% and 50% belong to the medium income category. This shows how the C+T distribution targeted mainly the vulnerable household in rural setting. The table 3 below gives details.

Table 6: Income category of households

Income category	Target	%	Control	%	Total	%
very poor	12	10%	6	5%	**18**	**8%**
poor	94	78%	50	45%	**145**	**62%**
medium	15	12%	56	50%	**71**	**30%**

rich	1	1%	1	1%	**2**	**1%**
Total	**121**	**100%**	**112**	**100%**	**233**	**100%**

The main source of income of (81%) C+T users and (79%)C+T non users is mainly provided by farming, other occupations are namely: employment by government or private, livestock, commerce, self-employment, handicraft and other sources which contribute overall to the sources of income with a very low percentage of less than 10% on both target and control group.

Table 7: sources of income for the households

Source of income	Target	%	Control	%	Total	%
Farming	98	81%	88	79%	**186**	**80%**
Other	1	1%	2	2%	**3**	**1%**
Livestock keeping	5	4%	1	1%	**6**	**3%**
Farming and Livestock	0	0%	1	1%	**1**	**0%**
Commerce	0	0%	4	4%	**4**	**2%**
Handcraft	1	1%	1	1%	**2**	**1%**
Employment by Government	8	7%	6	5%	**14**	**6%**
Employment by a private	5	4%	1	1%	**6**	**3%**
Self-employment	1	1%	1	1%	**2**	**1%**
Total	**121**	**100%**	**112**	**100%**	**233**	**100%**

The monthly income is between RWF10,000 and RWF 50,000 for 62% of the target households while the control group earn the same amount range. 18% of target household earn between 50001 to 100000, the control account 24% in that category. 11% of target household earn between RWF 100,001 to RWF 150,000in control 69% households earn the same amount, only 9% of target group are in category of income level above 150000, this category is represented by only 1% of control group. There was no related relationship between these level of income with Ubudehe category, mainly because some of target were active in changing their situation, or people who were categorized among vulnerable people and made extra effort to level their level.

Table 8: Average income per month

	Target		Control		Total frequency	Percent
Income level	#	%	#	%	#	%
10000-50000	75	62%	7	6%	82	57
50001-100000	22	18%	27	24%	49	18
100001-150000	13	11%	77	69%	91	7
150001-200000	8	7%	1	1%	10	4
200001-250000		2%	-	0	2	0

	2			
>250000	-	0	- 0	- 1
Total	121	112	233	12

Table 9: Household expenditures

Expenditures	C+T owner (RWF)	%	Control (RWF)	%	Variance	%
Food	22,466	35%	24,768	43%	(2,302)	-10%
Drinks	5,580	9%	6,725	12%	(1,145)	-21%
Clothing	6,766	10%	7,514	13%	(748)	-11%
School materials	4,646	7%	2,934	5%	1,712	37%
School fees	8,344	13%	5,388	9%	2,956	35%
Firewood	3,001	5%	2,794	5%	207	7%
Lighting	1,758	3%	1,371	2%	387	22%
Farm labour	8,039	12%	4,128	7%	3,911	49%
Agri-inputs	4,099	6%	951	2%	3,148	77%
Other expenses	115	0%	597	1%	(482)	-419%
Total	64,814	100%	57,170	100%	7,644	12%

Nutrition is taking the biggest portion of 44% and 55% of the respective household expenditures. Fuel wood and lighting takes about 8% of the household budget of the target group and 7% of the control group.

3.1.2 Household cooking related inquiry results

Kitchen situation

There are different types of kitchens ranging from the 3 stones open fire outside the main house to the well-constructed kitchen with improved cooking stoves installed inside with a smoke evacuation facility. 90% of kitchens were found to be separate from the main house while 10% are incorporated into the main house. 82% of kitchens had a rain water tight roof while the rest didn't. 84% of the kitchens were in a closed room while the rest were situated in an open space without walls. 68% of kitchen allowed smoke evacuation while 32% were showing difficulties to evacuate the smoke. 60% of kitchens have windows for smoke evacuation while 26% doors only. 62% of kitchens showed that smoke pollution is quite an issue since it had changed the kitchen walls into completely black while 30% kitchen showed a relatively good kitchen environment in this respect.. A chimney was found in 20% of kitchens. 38% respondents consider doors and windows sufficient to evacuate the smoke, while 24% of respondents considered simply the door as sufficient to evacuate smoke.

Other cooking conditions

Only 1% of household had a sand box to extinguish igniting firewood after cooking, other were leaving to put off itself while some used water to extinguish it. Only 1% had wonder box (heat insulator) to assist

them as fireless cooker reducing fuel consumption. The women stated that with no limit of money, they would like to change first the building materials of the kitchen followed by getting improved cooking stoves to be able to save fuel wood.

Cooking fuel characteristics for C/T users

89% of household use dried firewood. Those who use non dried wood, use it because they do not have better alternative, otherwise most of stove users appreciate the use of dried wood. If there was no financial limitation, still 37% of women would like to use fire wood as their domestic cook fuel, 33% prefer charcoal, 8% would use biogas and 3% LPG while 18% are undecided about the type of preferred cooking fuel to use. This might indicate that stove users are quite well informed on alternative cooking fuel types. 50% of cooking fuel is collected in the field while 46% is purchased which seems to indicate an increase of the part of bought by rural households compared to former figures. When asked what they would like to add on the issue of cooking energy, 88% of female respondents appreciated canarume/tekavuba as the best wood fuel saver which is needed everywhere, 12% requested support to increase rehabilitate their kitchen environment, 3% requested support to increase own trees, while 2 % requested professional installation of c/t.

The responsibility of fire wood collection

The responsibility of fire wood collection is literally on the shoulders of children (64% from whom mainly are girls) and of women (21%) making firewood collection at 85% a burden of women and children exclusively. The average time deducted for fire wood collection is 2 hours per day during normal periods while it goes up to 3 hours when the fire wood is scarce. The majorities of household stated that looking for fire wood is affecting their family since it is difficult work; it takes much of their time and a good part of their family earnings. Only 10% consider fuel wood availability sufficient, 25 % see it available in reasonable quantities, 30% get it hardly, while 17% consider it to be in short supply, only 18% get it from their own plot.

Type of cooking patterns

Table 10: Type of cook fuel used

Fuel Type	Percentage
Fire wood	98.3
Charcoal	0.9
Others	0.9
Total	**100**

The majority of respondents stated that they use firewood on daily basis, while others mentioned fuel are: charcoal, kerosene, electricity and agricultural residues. 51% households prepare cook twice in a day, 45% cook three times per day and 4% cook once per day. Those who cook three times explained that they do so because of their small children. 52% of household take a hot meal twice a day while 43% take it three times a day. Those who do not take a hot meal sometimes stated that the main reason is time consuming. 69% of households do cook beans, dry maize, and peas once to three times a week. 86% of households do

not soak beans, dry maize, and peas, only few confirmed to have knowledge of soaking dry grains before cooking them. When asked if they are ready to soak those dry grains before cooking only few responded positively. 99% of respondents could not identify any other type of food that requires to be soaked before cooking. Only few respondents knew any other cook fuel saving technique which could be used in their domestic cooking and all mentioned ICSS. Only few received training either from NGO's or their neighbours on cook fuel saving techniques. Few of households change their diet during periods of the year with higher fuel scarcity. They do so by cooking simple meal or reducing time of cooking dry grains.

Wood fuel availability and accessibility

Table11: Mode of firewood acquisition

Source	Percentage
collect in the field freely	42.9
bought to the door from supplier	32.5
bought in shop/market	15.6
bought from dealer imported	1.3
other	7.8
Total	100

23% responded to have wood lots, while the remaining rely on biomass collected from land of others. Those who possess woodlots, they are mainly of small size of less than 1ha. 68% of households confirmed to have reduced expenditure on wood fuel as a result of use of C/T. The average of fuel wood collected per day is 7kg which serves one to 3 days depending on type of meal cooked. The average of quantity of wood used weekly by household is 33kgs while monthly it amount to 254kgs. 43% of fire wood used in households is collected from the field, 32% is bought at door from suppliers, 16% is bought at the market or shop, 8% comes from other sources, while 1% is bought from dealers who brings from other locations. The average price per a stere of wood is 2,654 and vary greatly in size and from one region to another, where wood is scarce price is so much higher and where wood is available the price is low. The average price of charcoal per bag is RWF 4,063. The average monthly expenditure on fire wood is RWF 6742. While those who use charcoal spent RWF 7625. 71% of household consider fire wood as cheaper cook fuel while 29% consider charcoal as the cheapest.

C + T Stove appreciation

Direct observation confirmed at 76% that Canarumwe/Tekavuba allows firewood to cook well with high combustion efficiency [1]and less emissions[2], but this is not applicable when one uses fresh wood. 77% consider the height of the cooking pot resting on an integrated Canarumwe/Tekavuba ceramic liner as appropriate. 65% of C+T stoves were found in good condition without reproaches while 56% other stoves

[1]The percentage of the fuel's heat energy that is released during combustion. Combustion efficiency refers to the amount of the energy from the biomass that is turned into heat energy.

[2]The by-products from the combustion process that are discharged into the air.

needed urgent replacement. 52% of those who using C+T stoves use them as the main stove, while others alternate them with others to meet specific purposes like roasting maize, potatoes and so forth.

Table 12 : Stove use frequency(C+T users)

Category	Stoves in use	# of stoves	%
Target	Canarumwe + Three stone only	6	5%
	Canarumwe only	94	78%
	Canarumwe + improved charcoal	2	2%
	Canarumwe + Improved charcoal stove	5	4%
	Tekavuba + Improved charcoal stove	1	1%
	Tekavuba +canarumwe	2	2%
	Tekavuba +3 stones	3	2%
	Tekavuba only	7	6%
	Canarumwe + Darfur	1	1%
	Sub total	**121**	**100%**
Control	Three stone only + simple muddy stove	1	1%
	Simple muddy + charcoal	1	1%
	Simple muddy stove only	10	9%
	Darfur + 3 stones	1	1%
	Darfur only	10	9%
	Improved charcoal stove + three stones	3	3%
	Improved charcoal stove	11	10%
	Darfur +improved charcoal	1	1%
	Darfur only	20	18%
	Three stone only	51	46%
	Three stone only + Darfur	3	3%
	Sub total	112	100%
	Total	**233**	

For Target users only 84 % use either Canarumwe or Tekavuba only while 16% use C or T with other stoves. The majority at 53% of control group are still using the three stone cook stove for cooking. This shows how important the sensitization on importance of using ICS is crucial. Those who use 3 stones only amount to 19%. Those who use 3 stones in combination with other ICS stated that they use 3 stones for warming themselves, roasting maize and potatoes and cooking long time required food like beans and maize, and it happens 2 to 3 times in a week. This has significance on fuel consumption and subsequent wastage, and calls a need for sensitization.

72% of the target Households appreciate Canarumwe & Tekavuba stoves as the most wood fuel saving stove. Only 26% of C+T stove users stated that this type of stoves is easily accessible, while others confirm difficulties to get them. This seems to confirm that C+/T stoves are not readily made available and selling points are the only production cooperatives themselves.

Table 13: C + T Stove appreciation

Stove type	Appreciation	#	%	Subtotal	%
Three stones	No appreciation	49	86%		
	fuel saving	2	4%		
	fuel saving, Quick cooking	1	2%		
	fuel saving, comfortable	1	2%		
	fuel saving, no smoke	2	4%		
	fuel saving, quick cooking	1	2%		
	Subtotal	**57**	**100%**	**57**	**24%**
Canarumwe stove					
	fuel saving, no smoke	1	1%		
	fuel saving, time saving	1	1%		
	Cook quickly, no smoke	1	1%		
	Fuel saving and cook quickly, no smoke in the kitchen	1	1%		
	Very good stove	1	1%		
	easy to use	7	6%		
	fuel saving	34	31%		
	fuel saving, quick cooking	13	12%		
	fuel saving, clean	1	1%		
	fuel saving, comfortable	1	1%		
	fuel saving, durability, time saving	3	3%		
	fuel saving, no much smoke	1	1%		
	fuel saving, no smoke	8	7%		
	fuel saving, no smoke, quick cooking	1	1%		
	fuel saving, simple and easy to use	1	1%		
	fuel saving, time saving	22	20%		
	fuel saving, time saving, food smells good	3	3%		
	fuel saving, time saving, no concentration in kitchen	3	3%		
	fuel saving, time saving, no much smoke	2	2%		
	fuel saving, time saving, no smoke	2	2%		
	interesting to use it	1	1%		
	time saving	1	1%		

	Subtotal	**109**	**100%**	**109**	**47%**
Improved charcoal stove	No appreciation	11	61%		
	fuel saving	2	11%		
	fuel saving ,durability	1	6%		
	fuel saving, quick cooking	2	11%		
	fuel saving, clean	1	6%		
	fuel saving, no smoke	1	6%		
	Subtotal	18	100%	18	**8%**
Tekavuba stove	No appreciation	1	8%		
	fuel saving	2	17%		
	fuel saving, cleaned, quick cooking	1	8%		
	fuel saving, durability	2	17%		
	fuel saving, durability, time saving	1	8%		
	fuel saving, time saving	2	17%		
	fuel saving, time saving, no much smoke	3	25%		
	Subtotal	**12**	**100%**	**13**	**6%**
Double and Triple fixed mud stove(Darfur)	fuel saving, no smoke	1	5%		
	No appreciation	21	95%		
	Subtotal	**22**	**100%**	**22**	**9%**
Simple mud stove	No appreciation	11	73%		
	Fuel saving	4	27%		
	Subtotal	14	100%	14	**6%**
	Total	233		233	**100%**

61% bought the C+T while 30% received it freely, only 2% were own made especially by stove producers. Those who were given C+T freely received them mainly from NGOs, while others stated that they were given by government institutions or their neighbours. The C+T are mainly preferred at 60% for fuel saving, 16% for durability, 13% for cost which is relatively affordable, 6% for accessibility, 4% for easy handling while 1% for maintenance and use. 12% of households were found with ICS but do not use them. 88% stated no monitoring was done after acquiring the stove. Of the C+ T users 51% stated that they

know in their community, where to get people who are producing or repairing ICS, and 43% of them are capable of making C+T. 62% of household did not remember time spent cooking using three stones. 55% of C+T stated that they spent less or equal to 1 house cooking while 21% confirmed that they spend between 1hour and 2 hours. 82% stated they had been using three stones before embarking on ICS. 86 3 stone user did not have any feature for appreciating the 3 stones. 94% of Canarumwe stove highlighted it as a fuel saving stove, other appreciations were also mentioned, below table embody it clearly.

The benefits of C/T stoves in the eyes of C+T users

The significance brought by C+T include fuel saving at 64% of respondents, 22% stated that it decreased time of cooking, 8% consider reduction of smoke, 4% see it as an effective means for clean cooking, while 1% consider it to cook well but takes longer time. 7% of respondents stated that they had problems of respiratory and eye illness as a result of smoke. 91% C+T stove users highlighted that they are easy to operate and are very stable. 73% C+T users confirmed that their expectation of saving wood, cooking faster and reducing smoke were met.

Feedback from stove users on benefits, price and durability:

Stove producers confirmed that people who use the stoves including themselves prefer them mainly because of saving wood fuel, cleanness and durability. Although they stated that some are still considering it expensive especially very poor households. In response to such situations Kirehe PU lowered their prices up to RWF 500 for this particular class of people. Others would like to have a C+T stove but do not known the place where those stoves are sold permanently. Others state that they are not repairable, once they are broken; they need to be completely replaced by a new stove. Producers who are users confirmed that installed ceramic liners never broke since installation and stated that stoves can last over 5 years once they are well maintained. The durability reduces substantially on the C+T as portable version since they are generally not equipped with a metal cladding for cost reasons.

Stove use experience

The households stated that they have used the stove for 11 months on average. 59% stated they do not need any regular maintenance. While 24% highlighted that the maintenance needed is proper cleanness once it is installed properly. Only 13% households had skills on making maintenance of C+T stoves. The life time of C+T stove was estimated at 5 years once they are installed properly, but the period could be in less than 1 year if the stove is not installed, since children might play with it. The average cost of stove was found to be RWF1,733, the minimum price was RWF 1,000 while the maximum price was RWF 5,000 among C+T owners. 66% of C+T owners considered the price as adequate while 11% saw it otherwise; they stated that it is expensive. The adequate price proposed by stove household users is RWF 1,820. The minimum price being RWF 500 and maximum price was RWF 5,000. 59% households would like to pay the

stove in instalment, if so 42% would wish to by 1 stove in addition while 33% stated they would like to buy more than one stove. 75% stated that they are satisfied on the actual C+T stove price due to mainly of their performance namely: cooking quickly, durability, economy of firewood, fuel saving, good handling.

ICS sensitization, awareness raising

52% stated to have heard sensitization on CS while others did not. 92% of the respondents confirmed that if sensitization is done, non-users will adopt ICS because of the benefits. 96% have heard about environmental protection.

3.4Canarumwe +TekavubaStove Producers

The Government in the framework of an EWSA/PAC program to produce and distribute Canarumwe and Tekavuba firewood wtoves in rural areas, has installed C+T production units 15 districts (out of 30) of Rwanda including Bugesera, Kirehe and Ngororero, the target Dsitricts of this study. The survey conducted concerned the two Producer Cooperatives in Bugesera District situated in Nyamata and Mayange Sectors, the one existing in Kirehe District at Nasho Sector and the one existing in Ngororero District at Kageyo Sector. The total number of these 4 stove producer cooperatives (Association members) is 52 (54% female, 46% male on average). The member composition of the three production units is detailed in the table below:

Table 14: Composition of C+T stove production units

District	Sector	Female	Male	Total workers
Bugesera	**Mayange**	8	4	**12**
	Nyamata	7	5	**12**
Kirehe	**Nasho**	11	8	**19**
Ngororero	**Kageyo**	2	7	**9**
	Total	**28**	**24**	**52**

Most members had been trained in the framework of the EWASA/ PAC program in 2011, others replacing group members dropping out were trained on the job.

Table 15: cost of production vs revenue

Description	Production cost		Revenue		Profit (RWF)	
Items	1stove	100 stoves	1stove	100 stoves	1stove	100 stoves
Labor	2500	250000				
Iron sheet	1200	120000				
Nails	224	22400				
Overhaul cost	250	25000				
Total	4174	417400				
	Total		10,000	1,000,000		
				Total	5,826	582,600

Stove production

The stove production requires technical skills and commitment, the raw material is heavy and requires energy to be extracted and transported to the working place. These raw materials include mainly clay, sand, soft stones and soil. Significant amounts of firewood are required for firing stoves. Watching the stock of ready stoves is a continuous task. Apart from Ngororero stove producers who were getting clay and sand and soil nearby, others need to bring raw materials from far. Producers from Mayange Sector have to pay for a vehicle to transport clay while those from Nasho pay bicycle' riders who offer the same service. Mixing clay with sand or soft stone (imonyi) is a main task in production of ceramic liners since failing to mix thoroughly causes failures and/or substantial losses during firing. Most producers could not precisely indicate the proportion of clay-sand-soil, or clay and soft stones, they claim that they just feel with their fingers and tell if the mixture is adequate. The mixture was different in Ngororero compared to other production places. For instance in Ngororero, sand and soil are mixed with clay while in Bugesera and Kirehe, clay is mixed with soft stone. All producers buy clay, while sand, soil and soft stones are collected locally.

Table 16: Source of revenues and expenditures for C+T

PU	Expenses	Source of revenue	Other possible sources of revenues
Ngororero	1.Clay, 2.Transportation services 3.Polyethylene sheets, 4. firewood, 5.Taxes = rent 6. Security.	1. Selling stoves 2. Installing of stoves	1. Bricks making 2. Tiles making 3. Ornamental pots 4.Esthethic pots 5. Other domestic pottery products 6. Engage in other complementary businesses like buying tree planting *and selling timber and firewood*
Kirehe	1.Labour to extract clay, 2. Clay,	1. Selling stoves 2. Installing of stoves	1. Other pottery products to complement what they have.

	3.Transportation, 4. Polythene sheets, 5. sieve 6. Firewood, 7security, 8. Water, 9. Rent for stock, 10. Stamp, 11. Padlocks, 12.knife, 13.roofing nails, 14.Food and drinks, 15.Iron sheets,	3. Selling bricks	
Bugesera	1. Labour to extract clay, 2. Clay, 3. Transportation, 4. Polyethylene sheets, 5. Firewood, 6. Water, 7.Communication, 8Photocopying, 9. Drying place maintenance	1. Selling stoves 2. Installing of stoves	1.Other pottery products

Figure 1: Produced stoves	**Figure 2:** C+T firing kiln
Photo: Kageyo production site (C stoves) 	Photo: Kageyo site (kiln + clay) 

Direct production costs

The cost of production include: labour when people are engaged to extract clay, sand, soft stone and soil, cost of clay, hiring vehicles or bicycles for transportation, polyethylene sheets, firewood, water, taxes and watching the stock of products.

Table 17: Direct cost and mode of acquisition

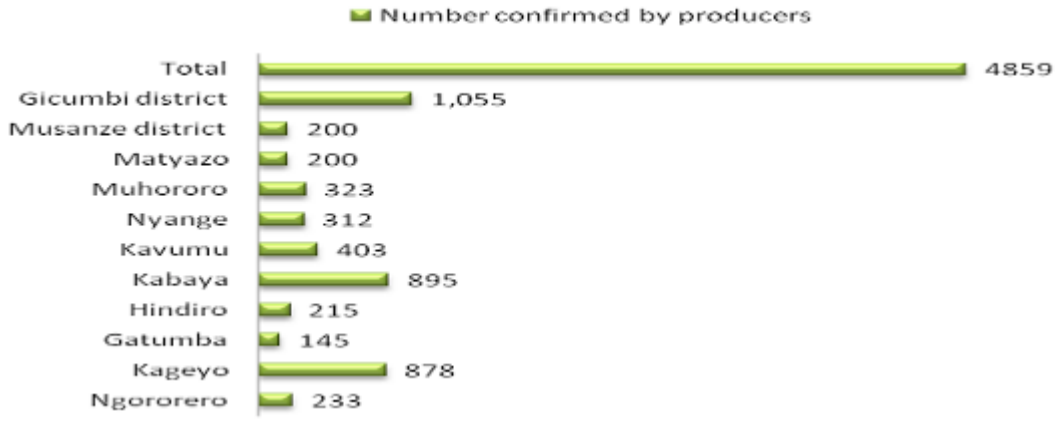
Sites	Direct cost	Mode of acquisition
Bugesera	Clay	Busing clay site
	Transport of clay/firewood & of stoves to the market	Local transport, its cost varies with transporter/distance to cover, usually from 10,000 to 30,000. Stoves sometimes are carried on bicycles when they are few
	Fire wood	Local plantations from 8,000 to 15% per kiln
Kirehe	Clay	Busing clay site
	Transport of firewood/ clay stoves to the market	Local transport, its cost varies with transporter/distance to cover
	Fire wood	Local plantations from 10,000 to 15% per kiln
	Labour	Local labour at rwf 1000 man day
	Water	Access from local connection at rwf 2, 000 per kiln
Ngororero	Clay	Busing clay site
	Transport of firewood/stoves to the market sometimes	Local transport, its cost varies with transporter/distance to cover, usually from rwf 10,000 to 36,000.
	Fire wood	Local plantations from rwf 7,000 to 15000 per kiln

There is no static cost for direct costs, each production has its own cost mainly for clay, transport, fire wood, labour and water. Some of costs are keep on changing due to negotiation during the purchase of products or services.

Stove distribution:

Stoves are usually carried on the head when they are being delivered to clients living close to the producers. In Bugesera and Kirehe bicycles are also used for stove transport and distribution. In most places, distribution of large number of stoves requires the use of a vehicle. Transportation is a key issue when it comes to distribution of stoves for sale. In most cases, buyers pay for transportation. The PU at Ngororero has consistent records of their stoves sales. Records from other PU's were irregular and missing some destination place.

Graph 1: Ngororero stove distribution



Production unit of Ngororero was able to widely distribute stoves to others districts and Sector. This has been enhanced by the grassroots leaders who were supportive in marketing and sensitization of C+T stoves. Stove prodders emphasized that when local authorities states importance of C+T is like instructing people to buy C+T, and they respect them. They insisted that their sensitization is less taken seriously and can only be effective at the vicinity of production. In the other cases, distribution of stoves was much more limited to the vicinity of the production unit because awareness was not much supported by local leaders. This implies to have successful distribution of stoves requires involvement of local authorities since they influence the consumer behavior.

Revenues from C+T stove production (Sub-title)

Production and sales performance

The production of stove is organized by the leaders of the production unit, and records are taken during that process to assign the man days and subsequent reward to the producers according how they have performed. The division of the work is made fair for everybody to participate actively. Men normally are given hard tasks to handle than ladies, and do not count any difference in rewarding as long as these were on their duties regularly. The cost of production includes direct and indirect costs of production, and was summed up in reference to the register's records and what they were able to remember which did not take part of the unregistered records. The average cost of production was rwf 294, it was less in Kirehe followed by Bugesera and Ngororero. In Ngororero despite their high cost of production and low price per unit, they registered higher profit per work, followed by Bugesera and Kirehe. This is due to their selling volume which was high and their number of group members was less. In all places, sales were going on well, but production is sometimes stopped when there is no demand or when the producers have to work in their

own firm especially during planting season. The selling in debt has been a discouragement to the group members, especially in Bugesera where producers decided to slow down the production at that cause.

Table 18 a: Overview of production and sales performance (including non-paid products)

Production units	Duration of production (months)	Stoves sold	Production costs (RWF)	Direct costs per sold stove	Revenues (RWF)	Average revenues per sold stove	# of workers/ members	Profit per PU	Profit per worker per month	Delivered but non-paid products (RWF)
Kirehe Nasho	20	3,236	752,010	232	4,224,270	1,305	19	3,472,260	9,138	587,000
Ngororero Kageyo	20	4,859	1,726,000	355	3,764,000	775	9	2,038,000	11,322	1,095,000
Bugesera Mayange	20	788	232,960	296	1,828,100	2,320	12	1,595,140	6,646	714,000
Total	60	8,883	2,710,970	883	9,816,370	4,400	40	7,105,400	27,106	2,396,000
Average	20	2,961	903,657	294	3,272,123	1,467	13	2,368,467	8,882	798,667

The 3 production sites show different business performances: with profit margins for the coop members (potters) between7.000 and 11.000 RWF per potter per month. The average is about 9.000 RWF. The study revealed that all Coops had given away number of stoves without finally being paid for.

Table 18 b: Overview of production and sales performance simulating payment of non-paid products

Production units	Duration of production (months)	Stoves sold	Production costs (RWF)	Direct costs per sold stove	Revenues (RWF) including non-paid stoves	Average revenues per sold stove	# of workers/ members	Profit per PU	Profit per worker per month	Delivered but non-paid products (RWF)
Kirehe/Nasho	20	3,236	752,010	232	4,811,270	1,487	19	4,059,260	10,682	587,000
Ngororero/Kageyo	20	4,859	1,726,000	355	4,859,000	1,000	9	3,133,000	17,406	1,095,000
Bugesera/Mayange	20	788	232,960	296	2,542,100	3,226	12	2,309,140	9,621	714,000
Total	60	8,883	2,710,970	883	12,212,370	5,713	40	9,501,400	37,709	2,396,000
Average	20	2,961	903,657	294	4,070,790	1,904	13	3,167,133	11,877	798,667

The second table shows the influence of these outstanding money ought to the cooperatives (in a case since more than a year): The average benefit per potter (Coop member) would have risen between 10.000 and 17.000, with an average of around 12.000 RWF per potter per month. Ngororero is by far the best performaing production unit with a profit per worker of more than 17.000 RWF

The sale price (at the production Cooperative) is fluctuating: inBugesera production unit (Mayange), it was maintained at 2000 RWF per piecewhile in other places prices for the C+T stoves varied between 500 to

3000 RWF in Kirehe and 1000 RWF for Ngororero. For some production units it was confirmed by their members, that the program subsidizedthe stoves with amounts of around 800 RWF per stove.

In the period of program implementation during 2011 until March 2012, stoves have been to a large extent bought and ordered by the program and other NGOs or projects. After the end of the program, the Coops had generally difficulties to switch to the open market of the District and production was very much hampered by the lack of a retailing system. The market for the C+T stoves established mainly in the vicinity around the production units. This didn't exclude, that with the support of local authorities, some production units could also sell farer away: Ngororero managed to sell to Gicumbi and Musanze Districts and Bugesera-Mayange sold also to Kayonza District. Although they have been widely appreciated for their fuel efficiency and relatively smoke reduced combustion, the market for the Canarumwe /Tekavuab stoves remained overall limited. All producers stated that they have not reached their full capacity of production

The limited expansion of the stove production and sale is also reflected when considering the actual penetration of stoves in the Districts of Bugesear, Kirehe and Ngororero. The following table shows, that between4 and 5% of the total number of households have benefitted from a C+T stove.

Table 19: Canarumwe/ Tekavuba Stove penetration (raw +secondary data)

District	Population (Census 2012)	# of households (av. of 5)	Stoves distributed	% of households served with one stove
Ngororero	334,413	66,883	3,604	5%
Kirehe	340,983	68,197	3,730	5%
Bugesera	363,339	72,668	2,871*	4%
TOTAL	**1,038,735**	**207,747**	**10,205**	**5%**

*It is assumed that each household is served with one stove

The Labor and time requirement for stove production

Stove production requires labor and time, in stove production planning such variables should be taken into consideration.

Challenges for Canarumwe /Tekavuba production units

- Lacking market development, retailing system; is crucial challenge in all districts, Ngororero seems an exception because of active involvement of local authorities in C+T sensitization. In addition, mechanisms were adopted to ensure sale of stoves. This include the health workers of the district

who were convinced that they should be role model in use of C+T stoves, and those who work in radical terraces were encouraged to buy stoves.

- Difficulties to transport the goods to remote areas, high transport prices discourages C+T producers to carry out distribution since no value chain exists for C+T stoves.
- Cooperatives as victims of unprofessional selling practices (without contract); all members of production units are not used for formal selling practices, for instance no contract was established between them and those who were buying their stoves at credit. This has handicapped the follow up of their money.

SWOT analysis and improvement proposals concerning C+T producer Cooperatives.

SWOT analysis of canarumwe / tekavuba stoves production

It gives the internal strengths of production unit to build on for defeating internal weaknesses. Externally, it gives opportunities to embark on for proper positioning and development. It gives also threat which can be avoided in proper strategic planning and execution.

Strengths	**Weaknesses**
1. Brand name of canarumwe/tekavuba 2. Recognized/supported by government 3. Ownership of technology of production 4. Unique products that respond to daily activity 5. Cost of raw material is relatively low 6. Possibility of practicing economies of scale 7. Size of group is easily manageable 8. The producers are the main actors of supply chain 9. Availability of raw materials 10. Materials are replaceable 11. pricing power is held by producer **12.** can influence the production outcome	1. Weak marketing skills 2. Price fluctuation due to external forces 3. Lack of skills to scale up the market and supply 4. Low skills in handling customers 5. Poor management skills 6. Lack of sufficient information on demand 7. Reputation is linked to the product rather than the group 13. 8.weak supply chain (no actors in some level) 8. High manpower required 9. Manual technology 14. 11.high unpaid debt burden 11. Work inefficiencies (no mastering mixing raw materials by all members and fire regulation of kiln). 15. 13. Lack of stock in different sectors limiting accessibility and availability of the products

Opportunities	Threats

16. Possibility of expanding market beyond district level 17. new markets available even within district 18. Possibility to embark on new pottery products like: tiles, bricks, ornamental vessels, etc. 19. Possibility of getting government support in marketing 20. Open doors for new related technology 21. possibility of starting satellite selling show rooms in different sectors 22. possibility of locating installers across the district, who can be selling agents 23. Possibility of networking with micro financial institutions and local leadership institutions **24.** possibility to collaborate with existing non-government organisation (ngo) for increasing market	25. Existence of substitute products 26. Volatile revenue since it is immediately divided by members of the group 27. High risk of intense competition since in every district they are many potters 28. New technology might bring what is better than C/T. 29. Internal competition would disintegrated the group 30. Lack of legal recognition as cooperative, brings limitations to access bank loan, and might threaten group property and sustainability

Table 20: Perspective for improvements

PU	Capacity development needs
Ngororero	Need of training on: 1. Group dynamics 2. Cooperative model 3. Marketing 4. Financial management, 5. Contract drafting 6. Client handling and price negotiation, 7. Book keeping, 8. Time management. 9. Shelterfor drying products. 10. Facilitation in cooperative registration. 11. How to make wonder box and manage fuel effectively.
Kirehe	1. Group dynamics; 2. Cooperative model; 3. Marketing, 4. Financial management and contract drafting 6. Client handling and price negotiation, 7. Book keeping, 8. Time management 9. Group need to be linked to 223 members of clubs of environment protection (located in all sectors) to serve as installers, 10. Dryingplace for products, 11. Facilitation in cooperative registration, 12. How to make wonder box and manage fuel effectively.
Bugesera	1. Group dynamics; 2. Cooperative model; 3. Marketing, 4. Financial management, 5. Contract drafting, 6. Client handling and price negotiation, 7. Book keeping, 8. Time management 9. Business coaching and mentorship. 10. Need of a safe place (cemented to avoid termites) for drying products. 11. The group needs to be restructured to allow people from the same place to work together, to be grouped according to their availability. 12. Facilitation of cooperative registration. 13. How to make wonder box and manage fuel effectively.

3.3 Canarumwe/Tekavuba Retailers

The C+T value chain is lacking, during survey 14 out of 15 the so called retailers are in reality C+T stove production cooperative members. The selling activity is carried out by stove producers, this handicaps the active positioning of stove producers, since there is no market system established for C+T stoves. When approached some potential retailers, many stated that they are not aware of such stoves, while others do not consider it in their priorities.

3.2 Canarumwe/Tekavuba Installers

Installers are technicians trained in fixing C+T stoves, some of them are potters producing stoves but most of them work independently and focus on installation. Those who are in the same time producers were initially trained by PAC (Practical Action Consultancy) but transferred since then their skill locally to community members. Installers work individually, they are not organized in Cooperatives. Total number of 38 individual installers has been interviewed (63% male, 37% female) out of a total of 52, 14 belonged to production cooperatives.

3.2.1 C+T Installation and related activities as a business

The main work of Installers is to provide a service consisting in permanently fixing C+T ceramic liners in a rapidly build-up mud kitchen hearth. (see photo in Annex). The amount charged for installing a Canarumwe ceramic liner is RWF 1,270 on average (this includes transport and installation fees). Prices vary from 500 to 5000 RWF. The amount charged for replacing a C+T stove is almost the same as installing it, and varies from RWF200 to 3,000 exclusive of the price for the liner and depending on the distance to the client. Only 13% of installers have been consulted for repairing the stoves formerly installed;57% of the repairs concerned rocket stoves and 43 % for Canarumwe, 84% confirmed that they have never been called to repair installed stove.

82% of installers know the origin of canarumwe /tekavuba stoves while 18% did not know about it. 53% of the installers have already made additional installations for their old clients. 26% of the installers affirmed that they can make a living out of this activity. The monthly estimated income for C+T installation is RWF 11,596.

3.2.2 Training, scope of services, satisfaction of clients

On average Installers claimed to install 5 stoves per week, 17 stoves per month, 49 stoves quarterly, 65 stoves per semester and 125 stoves per year. A majority of the installers (76%) stated that they visit their customers after installing the C+Tstove to find out if they need their services. Installation material is easily provided by farmers. A competence transfer has been observed in so far as 76% of the installers stated to have transferred their knowledge to an average of 16 persons per Installer. According to 97% of the installers their customers were very much satisfied with their services and the related charges. 37% of installers stated they faced problems of getting raw materials for stove installation e.g. fired bricks were

rare in some places, or bringing them from a distant place was burdensome. Other issues were; inappropriate location, since many households were still using open space for cooking and a mud hearth doesn't resist to the rain. 42% of installers recognized the rules governing their profession while others did not. 82 % of installers recognizing the causes of smoke within the kitchen incorporated a chimney for smoke evacuation. Installers are willing to continue their job and expand their work to other places.

3.2.3 Opinions about the quality of C+T

C+T stove appreciation

Table 21: Stove appreciation by the installers

Stove attribute	Percentage
Fuel Saving	40
Fuel saving + shorter cooking time	24
Best stove available	15
Fuel saving and good cooking	9
Fuel saving and comfort in usage	6
Fuel saving, time saving and het conservation	3

In comparison with other stoves, installers add that it is the cleanest stove and it is durable. It was confirmed by 79% of the installers that their initial clients influenced others to purchase the same stove. Others say that C+T stoves are rare products and promoting them when they cannot be found is quite difficult; this is due to deficient retail market. 87% of installers state that they can market C+T stove comfortably. 95% of installers confirmed the use of Canarumwe in their household while the others use rocket stoves.

C+T stove deterioration

The majority of stoves are deteriorated due to normal usage at 40%, while 28% stated that they got them when they hard slight damages, 8% stated too much fire, 4% highlight exposure to rain, 4% attribute damages to children and domestic animals. 3% see heat as the main cause while 16% confirm that no deterioration with proper care of stove. Below table express it.

Table 22: Reasons for stove deterioration

Reasons	#	Percentage
Normal usage	15	40%
Bought with the damages	11	28%
Use of too much firewood	3	8%
Exposure to rain	2	4%
Children and animals	2	4%
heat conservation	1	3%
No deterioration with proper care	6	16%
Total	38	100%

Constraints of the C+T installing business

C+T installers stated that 25% challenges are linked to transportation of the stoves ; 21% to lack of transport, capital, hard work and marketing; 18% to lack of customers for the stoves; 14% to raw materials, 7% to lack of raw materials and poverty, 7% to payment while 4 % are linked to few clients, and 4% to no new stoves no demand. These challenges can be summarized into 3 main categories specifically access to materials, poverty and marketing.

Linkage Of ICS Installers With MFI

The Umurenge SACCO has opened accounts for 45% of ICS installers, 18% work with Unguka bank, 3% are with BPR, 3% are with Urwego opportunity bank while 31% have no bank account at all. Despite that many are linked with the MFIS, 90% of them would like to get a loan but most of them fear approaching the MFIs, losing money or lack of sufficient information on loan management. To them MFIsare there to safe keep their money. The average loan needed by each installer was estimated at RWF193,939. This amount is to be used not only to use in business of installation of C+T but also to meet their basic needs so that they can be free for the concerned business. Those who confirmed to be loan eligible for loan are 42% only, 29% declared that they are not eligible while others are not aware about issue of eligibility. Among those who are eligible only 3% consider getting a loan as an easy exercise, while others see it as a difficult task.

SWOT Analysis

This is an evaluation of the strengths, Weaknesses, Opportunities and Threats to the C+T installation as a business.

SWOT analysis for Canarumwe / Tekavuba installers

Strengths	Weakness
1. Willingness to develop themselves and expend business for income generation **2. Encouragement from their spouses** **3. Dependence on other sources of income like agriculture and livestock keeping** **4. Stove installation complement other income generation**	1. Not a regular job 2. Difficult to make commitment for payment per month 3. Limited physical capacity 4. Individualism 5. Lack of means for transport and long distance discourages the business

5. Ownership of technology **6. C/t are good stoves, fuel saving, easy to handle** **7. Possibility of practical demonstration** **8. Support from family members** **9. Physical strength for labour**	6. Illiteracy, Low level of education 7. Living in vulnerability of poverty forces to prioritize for survival not for long term investment 8. Insufficient of marketing and negotiating skills 9. Insufficient information on benefits of working in a group 10. Poor financial management skills 11. poor customer care 12. Insufficient skills to manage loan profitably 13. Inadequate relationship with MFI 14. Quick discouragement

Opportunity	Threats
1. Availability of MFI to increase capital **2. Strong supporting government policy & leadership** **3. Existence of untouched markets** **4. Possibility of employing others** **5. Free sensitization** **6. Non integrating gender policy** **7. Good opportunity for youth employment/other jobless** **8. Possibility of networking with other existing institutions** **9. Institutional support for formation of cooperativemarket**	1. Fluctuating and uncertainty and non dependability of the market 2. Fear for working in a loss of income and credibility 3. Fear of competition since much unemployment 4. Temporal nature of the job 5. False promises when payment is not immediate 6. Limited supply of canarumwe/tekavuba stoves 7. Harsh conditions of the climate (too much rain)

3.5 Testing of stoves and testing results

The inquiry has undertaken a series of WBT and CCT tests of firewood stoves the results of which are presented in the following graphs. Testing concerned mainly the stoves found in the sample households but also some models more recently introduced in the country.

The stoves found in the sample (please refer to stove pictures in the annex):

- Traditional three stones fire and first generation ICS ('Rondereza – Darfur type' fixed stove) ;
- Locally produced clay and mud stoves (Gisafuria, Kibote);
- Canarumwe and Tekavuba ceramic stoves (fixed and portable)

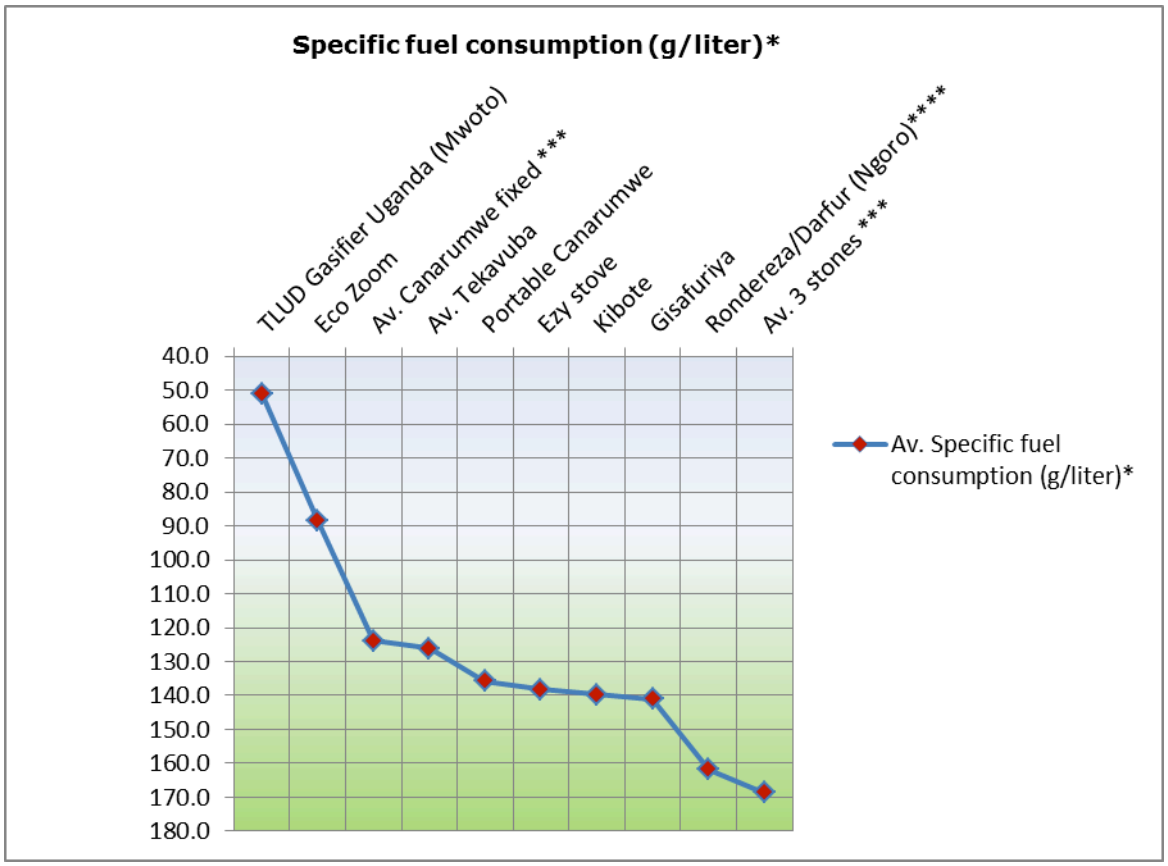
Newly introduced stoves which have been tested in comparison to the former ones are:

- Ezy and Eco Zoom stoves, imported rocket stoves;

- Karundura stove, a TLUD (Top Lit Updraft) gasifier locally produced.

The testing has been done by the Rwanda Tumba College of Technology (TCT) in March and early April 2013 except for the TLUD Karundura. For this stove, we have indicated the testing result of CREEC Uganda from April 2012 for the Mwoto Gasifier stove which is the original model of the Karundura.

Graph 1: Comparison of fuel efficiency of firewood stoves:



The reference figures for this graph are the following:

Table 23 : WBT results in detail

	WBT Results		
Stoves	**Av. Specific fuel consumption (g/liter)***	**Time to boil (min.)****	**Thermal efficiency**
TLUD Gasifier Uganda (Mwoto)	51.0	17.1	41.0%
Eco Zoom	88.5	29.5	28.5%
Av. Canarumwe fixed ***	123.9	29.9	21.0%

Av. Tekavuba	126.2	29.3	20.5%
Portable Canarumwe	135.8	29.2	18.5%
Ezy stove	138.3	46.0	27.5%
Kibote	139.8	21.4	17.5%
Gisafuriya	141.1	24.8	20.0%
Rondereza/Darfur (Ngoro)****	161.8	34.0	17.5%
Av. 3 stones ***	168.6	29.9	16.3%
* Grammes of firewood needed for 1 liter of water brought to boil. Average of CS + HS			
** Minutes needed to bring 5 liters of water to boil. Average of CS + HS			
*** Averages from all tests done for this stove type			
**** Second Rondereza tested has been excluded			

In the following, I will add a graph about the CCT results. If they are coherent with the WBT results (Jörg)

Graph: CCT results in comparison

Penetration and efficiency of stoves

Since the late 80ies, both, firewood and charcoal stoves have been improved with strong Government commitment essentially in order to protect the shrinking forest resources. Today, it is estimated that 50-70% of rural families and more than 70% of urban ones are using improved firewood and charcoal stoves (ICS)

In the light of the mentioned testing results (in a limited number of three Districts) we are concluding on the following 'efficiency levels' summarised below:

Table 24: Fuel efficiency comparison (Water boiling test results; March 2013)

Stoves	level	g/liter *	Comments
TLUD Gasifier	1	51	Highly efficient firewood stove (locally produced)
Eco Zoom	2	90	Highly efficient rocket stove (imported)
Fixed Canarumwe/Tekavuba	3	Between 120-130	Middle range stoves: Recently introduced Canarumwe and Tekavuba ceramic liners (locally produced).
Portable Canarumwe, Kibote, Gisafuria, Ezy stove,	4	about 140	Lower middle range stoves: Locally produced clay stoves except the newly imported Ezy stove;
Rondereza (Darfur type) and 3 stones;	5	160-170	Traditional three stones fire and first generation ICS;
*** Grams of fuel needed for 1 liter of water brought to boil.**			

The stoves found in the sample households can be attributed to the levels 5 to 3, comprising firewood ICS of the first generation followed by ceramic and mud stoves (Gisfuria ,Kibote) and the C+T stoves which are in fact the best performing stoves in the sample but which have until now a limited penetration in the country (between 4 and 5% of households inthe 3 target Districts)

But efficiency of stoves has largely increased since. The following table indicates the fuel efficiency increase based on the presented WBT results as follows:

Table 25: Fuel efficiency fuel efficiency increase based

	WBT Results March 2013			Fuel efficiency comparison	Fuel efficiency increase
Stoves	**Av. Specific fuel consumption (g/liter)***	**Thermal efficiency**		**% of fuel consumption compared to 3 stones**	**% fuel efficiency increase to 3 stones**
TLUD Gasifier Uganda (Mwoto)	51.0	41.0%		30%	70%
Eco Zoom	88.5	28.5%		52%	47%
AV.TLUD Rwanda (Karundura)***	101.8	21.0%		60%	40%
Av. Canarumwe fixed ***	123.9	21.0%		73%	27%
Av. Tekavuba	126.2	20.5%		75%	25%
Portable Canarumwe	135.8	18.5%		81%	19%
Ezy stove	138.3	27.5%		82%	18%
Kibote	139.8	17.5%		83%	17%
Gisafuriya	141.1	20.0%		84%	16%
Rondereza/Darfur (Ngoro)****	161.8	17.5%		96%	4%
Av. 3 stones ***	168.6	16.3%		100%	0%

C+T stoves have reached a fuel efficiency increase of 27% compared to 3 stone fires whereby actually available firewood ICS like the Eco Zoom and in particular the TLUD Gasifier pyrolising biomass to charcoal, reach an increase from 47 to 70%.

The study seems therefore contribute to an important statement concerning the performance of the firewood ICS sector in Rwanda:

If penetration of ICS is relatively high in Rwanda, fuel efficiency improvements have remained modest.

Given the low penetration of relatively efficient C+T stoves and the statistical absence of highly efficient firewood stoves in the country, there is an urgent need to contribute to the sustainable, market based penetration of modern, efficient firewood stoves in order to reach the GoR target of a 100% penetration and use of improved cook stoves in the country, to decrease the consumption of biomass for energy. This environmentally friendly policy is in the same time a guarantee to reduce the important health and death

toll caused by indoor air pollution from unclean biomass cooking. For the value chain to be functional all major stages of value chain need to be in operation. To have an effective system which is beneficial to the consumer, Government and Non Government organizations need to intervene, especially for empowerment and marketing.

Recommendations

- **National ICS survey**: a new and scaled up survey needs to be carried out in the country to know the status of ICS in rural and urban areas. This will aid in planning of the biomass sector. The three districts for which the survey was conducted, might not be enough to portray the whole country status.

- **Training**: ICS producers, installers and retailers need to be trained in enterprise development and business skills (marketing, product branding, quality assurance, etc.) while end users need to be trained on careful handling of ICS and management of firewood during cooking. In turn the trained candidates will be facilitated to train their counter-part and who will join ICS value chain.

- **User focus**: The user should be at the core of any new ICS development i.e. stove developers need to make regular consultation with stove users and their views taken on board. This fosters the acceptance of the new technology and the users feel part of the process.

- **Finance**: There is need for linking value chain actors to micro finance institutions where rural producers, installers, marketers/distributers, retailers and households with very meager resources can benefit from ICS technologies. To work well targeting grouped people would be efficient if coupled with training, and research.

- **Carbon finance**: The entire market chain need to be made aware of the potential benefits they could accrue if they register their projects. The existing carbon players in the country need to make sure the financial benefits reach all the stakeholders in ICS market chain.

- **Awareness**: ICS market is greatly untapped. The general public needs to be made aware of the benefits of ICS, where to get them, how to buy and what they are supposed to look for in an ICS (quality indicators).

- **Quality:** The government effort to make public the standards agreed upon by the ICS stakeholders would be indispensible.

- **Availability of fuelwood**: ICSupscaling should go hand in hand with tree planting program which requires joint effort of Government, Non Government organization, private sectors and farmers for the project to be sustainable.

4. CONCLUSION

Rwanda's population (2012) stands at 10,537,222 with an average of 5 members for every household, and an average annual growth rate of 2.6% and the density at 416 which is the highest in the East African Region. The country counts 2.5 million households mostly in rural areas. With 99.5% of the rural households using wood fuel for cooking dominated by firewood at 79.1% of households, this in turn heaps the burden on women (21%) and children (64%) who spend most of their valuable time collecting firewood. The conventional 3 stone cook stove, despite being common since it is available free of charge, has a lower thermal efficiency (approximately 15%) which translates to more fuel wood consumption. carbon emissions and associated IAP. The study indicates the level of penetration of C/T is 5% on average in target districts, which indicate good market of C/T. It is possible to increase the market of C/T, since the users appreciate it for fuel saving, time saving, cleanness, and its price is affordable. This will require involvement of local authorities in sensitization of C+T.

There is relatively high level of awareness (60%) of the fuel efficiency of C/T ICS. What needs to be enhanced is the awareness on benefits offered by C/T stoves in both rural and urban respectively, since it allows the use of the whole wood for cooking energy. The C/T installation done did not take into consideration emissions, and no chimney was included in installation of C/T. This can be corrected to enhance cleanness of the kitchen and avoid emission. With proper standardization of ICS and testing capabilities in the aspects of efficiency and carbon emissions; C/T users will be better off and will get value of the money spent on C/T.

There is no values chain for C+T, since the stove producers are only active. There is a need to initiate cooperatives of installers, since those who do installation are not organize in cooperative and their individualism cannot serve the public effectively. The key to improve the value chain is through strengthening supply and enhancing demand by improving the production and distribution of C/T ICS. This can be achieved by promoting and strengthening of cooperatives and equipping them with skills on efficient technical aspect of production and management; linking up to microfinance programs to provide

finance both the users to purchase the ICS and producers/retailers /installers to meet their costs before sale; creating an enabling environment through government/NGO marketing will be appropriate.

There is no retailing system, this can be initiated so that the market of C+T to be available. Market infrastructures and awareness are required to enable the rural households to know where to purchase C/T ICS. With proper quality standards, quality ICS producers will not have to lose out to sub-standard stoves which are sold at very low prices. C+T can be considered as a widely accepted, affordable intermediate technology. Together with more efficient stoves, they should be part of a ICS market development which needs most urgently a retailing system.

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