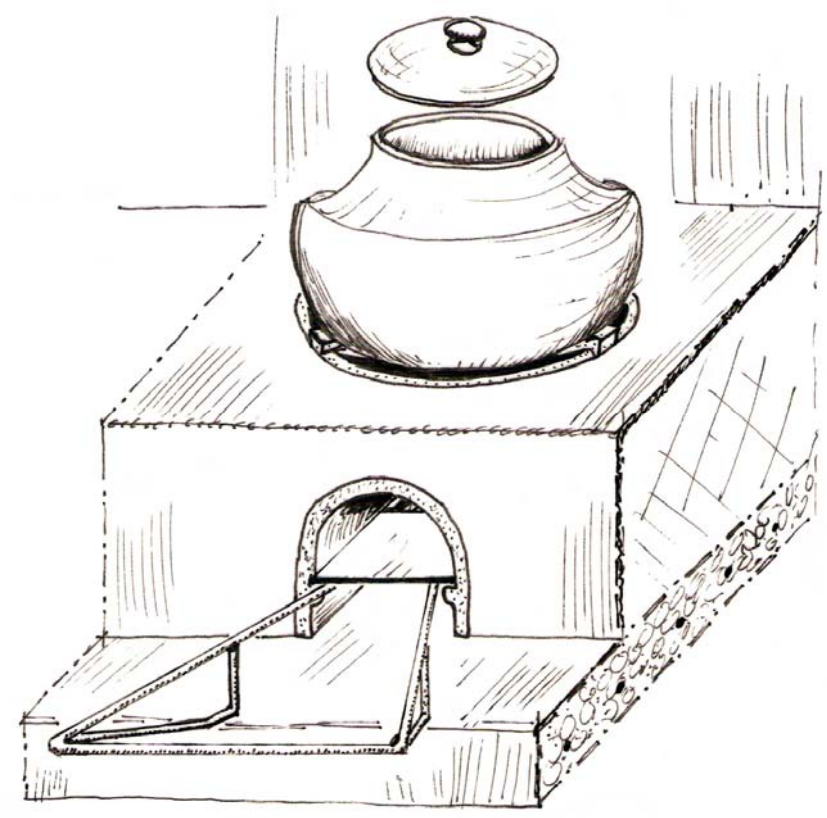
CARITAS ~ HUDEC

Improved Cooking Stove (ICS)

Terracotta One Pot (TOP)

Livelihood and Enterprise Development
Related to Permanent House Construction

Tsunami Relief & Rehabilitation Programme ~ SOA 03/2005



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Working for a Just World

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ABSTRACT

An Improved Cooking Stove (ICS) has been developed and field tested for local manufacturing in the northern Sri Lanka. The Terracotta One Pot (TOP) ICS has three components: the elbow-shaped burning chamber, a loose metal plate with grill and a terracotta pot support. The elbow-shaped combustion chamber is based on the "rocket stove" principle with an insulated exterior. Demand for the ICS is generated through demonstration in the new houses and the organisation of local entrepreneurs. The increased firewood efficiency (50%) of this TOP-ICS, in comparison to the more open traditional cooking stove, saves several hours in firewood and biomass collection per week, as well as cooking time. The TOP-ICS also reduces smoke and air pollution in the house and, with that, may reduce respiratory diseases and health expenses. Women and children can use the time saved for other activities, such as education, recreation, and income generation. The manufacturing of the TOP-ICS generates business and income for small entrepreneurs, while at the same time reduces dependency on non-renewable fuels. The TOP-ICS is part of the overall rehabilitation process and livelihood development in the tsunami-affected regions.

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1. INTRODUCTION

More than 35,000 people in Sri Lanka perished in the tsunami of 26 December 2004 and hundreds of thousands of people were left without housing and employment.

Household articles and cooking equipment from 100,000 houses were destroyed. While the construction of permanent houses considers roads, electricity, sanitation and sewerage as integral components in the overall tsunami rehabilitation process, cooking equipment and furniture development are often seen as separate issues. The first priority of the beneficiaries of the new permanent houses is food preparation and equipping the kitchen.

Although the majority of the low-income population is accustomed to cooking on wood fires, the economic setback caused by the tsunami makes it difficult to even consider upgrading their fuel source to kerosene or LPG gas. Purchasing new equipment and the recurrent expenditure of buying fuel is a heavy burden on their limited budget. However, these other types of fuels do not demand the daily time-consuming activity associated with firewood collection, which is becoming ever more difficult with increased population densities.

Cooking is an essential part of the household activities, consuming large amounts of time in food preparation and cleaning up afterwards. This time spent is substantially increased for those families needing to collect firewood from the bush. People tend to move away from biomass burning to higher grades of fuel (charcoal, kerosene and gas) to eliminate this burden and reduce cooking time, as these other types of fuel burn more efficiently than the biomass in their current stoves.

Even if a family has the means to buy a gas stove, using it for all their cooking needs is often too expensive and they revert back to cooking partly with a firewood stove, even if the wood needs to be purchased. This is partly related to the traditional method of food preparation requiring long simmering. This method is possible with the traditional stove because logs are used.

The development of an Improved Cooking Stove (ICS) and its manufacturing by local entrepreneurs will not only reduce the time spent on firewood collection and cooking considerably, but it will also delay the purchase of cooking equipment operating on non-renewable fuels, requiring foreign currency for their importation. For this reason, the introduction of ICS's is being promoted by the Ministry of Power and Energy.

The common cooking stove consists of a hearth in the kitchen and two fire points on a low concrete shelf (picture right). This hearth is fuelled with firewood and biomass. Changing the traditional stove with an ICS will require a change in cooking behaviour, regular attention to the fire and feeding smaller pieces of firewood into the ICS. The person interested in an ICS needs to balance the advantages with the disadvantages.

This paper covers the development of the Terracotta One Pot (TOP) ICS by Caritas-Hudec for the Jaffna-Vanni region.

2. THE TARGET GROUP

The target group is currently moving into the newly built permanent houses. In the kitchen of most houses is a chimney hearth with a concrete cooking shelf at a height of 1 ft. 9 inches. A tripod is used for placing the cooking pots over the wood fire. The logs are seldom extinguished after cooking; either because it is difficult to rekindle the fire or for rekindling some kerosene is required, incurring an extra expense. The result is continued firewood consumption after the cooking process is finished.

Due to inefficient burning, the cooking process is long and large amounts of biomass need to be collected or purchased; up to 3-4 kg per day or 20-25 kg per week for an average household of 5-6 members. In the urban areas, the cost of firewood ranges from LKR 80 to LKR 140 per month for a family of two adults and two children[1]. It is the task of the women and girls (gender specific) to collect firewood (preferably branches) and biomass (palm leaves and coconut husk), as well as do the cooking. Dry firewood is hard to come by in the rainy season and large quantities must be timely collected and stored.

The substantial time involved in firewood collection (minimal 6 hours/week) and cooking (14 hours/week) does not give women time to engage in other more productive activities. In the more concentrated village settlements established after the tsunami, the time required for firewood collection is expected to increase and more people will need to revert to purchasing biomass.

The time saved with the improved TOP-ICS is estimate at minimal 3 hours/week/household on firewood collection and another 3 hours on cooking, as the flame is hotter and thereby the speed of cooking is faster[2].

When firewood has incomplete combustion[3], smoke emissions are considerable and pots will blacken with soot. Smoke inhalation can negatively affect the cook's (women and girls) health, cause respiratory diseases and reduce general health or resistance to diseases. The smoke in the house does, however, reduce slightly the number of mosquitoes and flies. With the TOP-ICS smoke emissions will be reduced, benefiting the cook's health and pots will be easier to clean as there will be less soot.

> *Comments from a TOP- ICS user:*
> *I never use the normal stove since the time I got this stove because of the fact that the time and firewood consumption for cooking is very much less. My mother, living next to me, uses this stove to prepare morning meals in order to send my father to work in time. When visitors come I am able to offer tea in no time (she demonstrated with the boiling of water in a kettle). It took only seven minutes and with very small amount of tiny firewood.*

The general assumption of the villagers is that they will switch to kerosene or LPG gas when they have the additional funds to do so. The overall cooking time saved and the convenience of using imported fuel is obvious. Yet most houses will be fitted with a traditional, inefficient cooking stove as a back-up system. The actual reality in the Jaffna and Vanni districts is that, on average, people do not have sufficient funds to finance fulltime use of cooking with kerosene or LPG.

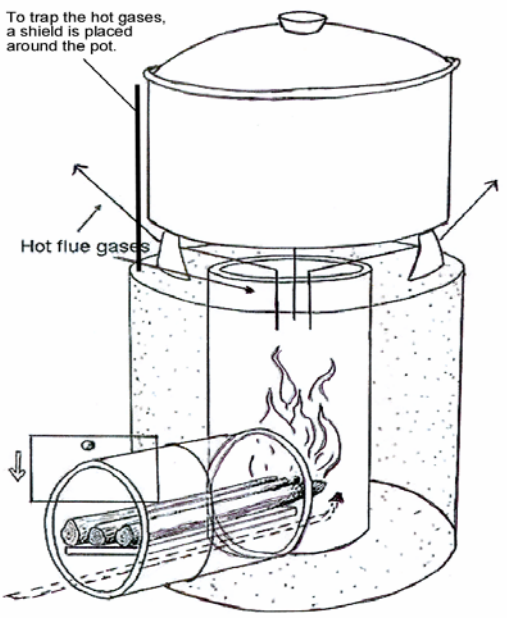
[1] In 2006, 1 USD = LKR 105.

[2] This is based on figures from ICS programmes in other countries. Preliminary measurements with the Jaffna population confirm these estimates. Measurements are ongoing.

[3] Yellow flames are a sign of incomplete combustion due to lack of aeration, low temperature and high moist content.

3. ICS TECHNOLOGY

The technology of the TOP-ICS is based on the existing "Rocket Stove" developed by Aprovecho, along with Dr. Larry Winiarsky (see sketch below). All elbow-shaped ICS's have the following aspects and components:



a) Thin wood pieces allow a better combustion.
b) Air enters from below the fire position and improves combustion.
c) The metal plate and grill are essential features for minimal air entry above the fire and enhanced air entrance from below.
d) The small, elongated burning chamber increases the temperature and allows complete burning of the wood gasses. The size depends on the overall size of the stove[4].
e) Insulation of the burning chamber increases the burning temperature and therefore completes the burning of gasses.
f) The complete burning of the firewood produces little amounts of ash residue. It also reduces the amount of unburned gasses and with that the amount of smoke or soot.
g) The hottest point is just above the flame, about 4-5 inches above the burning firewood.
h) The narrow space between pot and outside shield increases heat transmission to the pot.
i) The heat of the fire can be regulated by adding or removing sticks.
j) Removal of all the sticks quickly extinguishes the fire and stops further firewood consumption.

Disadvantages of this type of stove are:

- Most ICS's require thin pieces of wood having a cross section of about 1-1½". This means more chopping of firewood. Thin wood sections burn much faster than thick wood and allow regulation of the heat.
- The person tending the fire needs to constantly feed the burner to maintain adequate heat during the cooking process.
- The fire does not emit light because it is totally enclosed; good, hot combustion has only blue flames.
- There will be no charcoal remains and a little amount of ashes.

Main advantages are:

- ✓ About half the amount of firewood is needed as compared to the traditional stove.
- ✓ Time saved in firewood collection or money spent on the purchase of firewood is reduced by half.
- ✓ Cooking pots blacken less with soot, requiring less time in cleaning.
- ✓ The TOP-ICS is made of locally manufactured terracotta at low cost (LKR 300-350).

It is important that these aspects of the TOP-ICS be properly explained to the user. By keeping the lid on all the cooking pots the firewood efficiency will be further increased.

[4] In one case, the height of the burning chamber was reduced because the villager wanted the flames to touch the pot as with the traditional fire. However, by doing so the efficiency of the ICS is reduced.

4. TERRACOTTA ONE POT ICS

While the Terracotta One Pot (TOP) ICS design is based on the principle indicated in the former chapter, it has been modified to conform to the local cooking practices common in northern Sri Lanka.

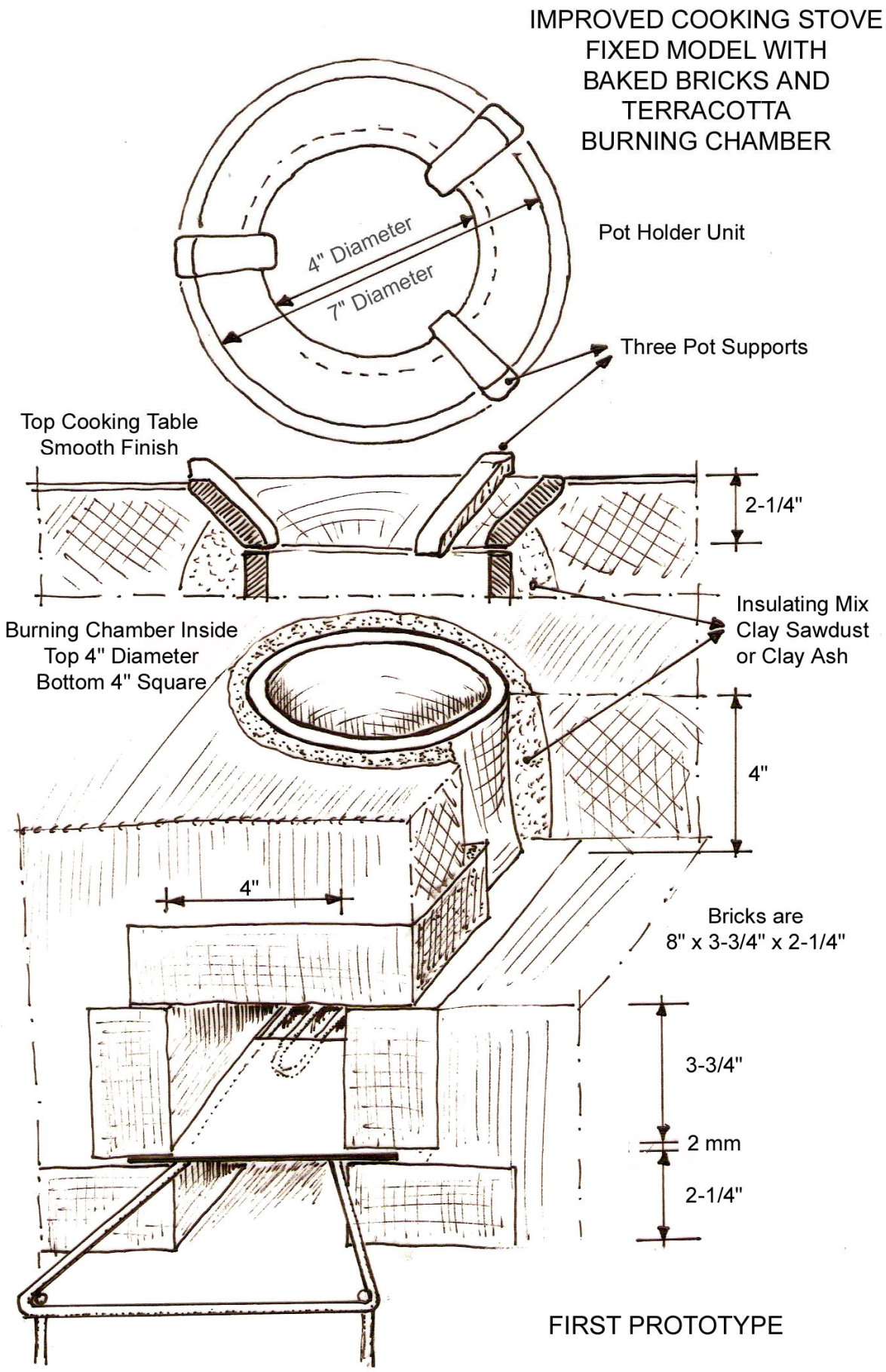
The TOP-ICS can only be effectively introduced once the user is comfortable with its use and the changed cooking behaviour associated with the new design, the latter being the biggest obstacle. It is one of the reasons why only slight modifications can be made at this time and why the user of the stove needs to be convinced by peers of its usefulness, as compared to the traditional cooking method. The benefits (time saving, safer fire, less smoke and soot) must be experienced by the user.

First TOP-ICS Prototype

The material used is clay, being generally available. The local pottery industry in Sri Lanka uses good quality clay for making large pottery, as well as stove components. In many houses a simple terracotta pot support is used instead of the metal tripod.

The TOP-ICS was first field tested by using common burned bricks for the elbow entrance, upon which the metal plate with grill was laid. The elbow-shaped entry channel was completed with other burned bricks. Only the upper part of the burning chamber and the pot support was manufactured in terracotta by a local pottery shop. A potential problem of this design was that various sizes of bricks were locally available, causing a change in the dimensions of the stove if people bought the wrong bricks. Also the total cost of the seven burned bricks was considered high.

The burned brick construction with the terracotta upper burning chamber and pot support was plastered with mud to insulate and create a working space next to the fire. Some villagers constructed the stove on the elevated shelf in the kitchen, but in some transitional shelters, the stove was placed on the ground as is commonly done in rural houses (see picture). The drawing on the following page gives the details of the inside construction of the first prototype.


IMPROVED COOKING STOVE
FIXED MODEL WITH
BAKED BRICKS AND
TERRACOTTA
BURNING CHAMBER
4" Diameter
7" Diameter
Pot Holder Unit
Three Pot Supports
Top Cooking Table
Smooth Finish
2-1/4"
Insulating Mix
Clay Sawdust
or Clay Ash
Burning Chamber Inside
Top 4" Diameter
Bottom 4" Square
4"
4"
Bricks are
8" x 3-3/4" x 2-1/4"
3-3/4"
2 mm
2-1/4"
FIRST PROTOTYPE

Changes to the First Prototype

- The seven burned bricks and upper burning chamber have been replaced with a terracotta unit.
- The external support of the metal plate has been extended to allow longer firewood to lay on the support.
- The metal plate with grill can slide in and out of the terracotta unit for cleaning the ashes or repair. The metal grill will burn through in one year.
- The pot support is slightly bowl-shaped and one inch wider in diameter, allowing 8" pots.

Annexe I provides final drawings of the modified TOP-ICS.

Double Burner Stove

A baked clay double burner pottery stove design exists in Sri Lanka. This is also better than the traditional stove because it saves firewood, although not to the extent of the above described TOP-ICS having an elbow-shaped construction with low air intake. The unit depicted (without pots) costs LKR 200 in Kandy, demonstrating that complex designs can be manufactured at low cost.

In this double burner stove design, the fire's flue gasses from the first burning chamber flow to the second pot and then to the outside. In this way two pots are heated at once. The model works well if both pots are placed on the stove and the first pot closes off the top of the burning chamber. Metal pots allow a better heat transfer than clay pots.

This double burner stove is less efficient than the TOP-ICS in four aspects:

(1) There is no air intake from below the fire. This will result in incomplete combustion and yellow flames.
(2) The distance between the fire and the first pot is too small, not utilizing the hottest area of the flame.
(3) The burning chamber is not insulated. However it is possible to insulate the entire stove.
(4) The hot fire flue gasses are not sufficiently engulfing the entire bottoms of the two pots.

Most villagers like having two separate burners. In the future, a double burner TOP-ICS can be developed.

5. TOP-ICS PROMOTION AND DISSEMINATION

Experience shows that neighbour-to-neighbour promotion is the most effective method to ensure success of a new product. Villagers tend to value and respect the opinions of their peers, when this is based on personal experience and testimony.

Demonstration of Prototype Models

To make women aware of the features and possibilities of the TOP-ICS, local demonstration in a real household situation by a family who has been using the ICS for an extended period is required. The user can then explain how it changed her life and cooking behaviour; giving the pros and cons. This is the best method to convince others. Prototype TOP-ICS models need to be installed in selected households under the following conditions:

a) The household spends substantial time on firewood collection or pay for firewood. When firewood is either readily available or very cheap, the economical benefit is little[5].
b) The household uses firewood and biomass as their principal cooking fuel.
c) The household needs to measure (weigh) the total amount of firewood used on a weekly basis. The new supply of firewood is weighed. At the end of the week, the balance is weighed and the consumption calculated. For this they need a simple spring-scale.
d) The household must record the number of meals cooked on a chart (see below).
e) The household must be willing to receive visitors in the kitchen and explain the functioning, savings, advantages and disadvantages of the TOP-ICS.
f) The household needs to provide feedback information to the animator who will visit the same villager after a few weeks to collect the information.

Registration Form - Firewood Consumption for Cooking per Household												
Name TOP-ICS Owner:									**Measure 0.1 kg Precision**			
Village:					**Number of Adults:**				A. Total kg of firewood at the start of the week	B. Total kg of firewood added during the week	C. Remaining amount of firewood at end of week	D. Total firewood used during week. D=A+B-C
House:					**Children under 6:**							
	Number of Meals/Day (child < 6 yrs = 1/2 meal)							**Total Number of Meals**				
	Monday	**Tuesday**	**Wednesday**	**Thursday**	**Friday**	**Saturday**	**Sunday**					
WEEK 1 Breakfast												
WEEK 1 Lunch												
WEEK 1 Dinner												
WEEK 1 Tea												
Total												
Average use of firewood per meal = Total D divided by total number of meals												
Name of Record Collector:									Date:			

[5] In one case, shortly after the tsunami, men returning from fishing would pick up large branches on the way home. Women were not involved in firewood collection and did not see any benefit in the ICS.

Promotion Team (Animators)
The promotion team should select rather intelligent recipients who can understand the principles of the TOP-ICS and can explain the same to others. It also means that the household should have an adequate status in the society to accept visitors in the kitchen[6].

A technically educated animator needs to explain the advantages and disadvantages of the model TOP-ICS to the recipient. The animator is also responsible for assembling the data into a table/chart and reporting on the experiences of the villager.

> *An ICS is not designed for the poor,*
> *but rather to save time, money, health and the environment.*

Efficiency Testing
In order to provide clear data on the efficiency of the ICS, the water boiling test provided in Annexe II should be realised by the promotion team for both the traditional stove and the TOP-ICS.

Marketing Strategy
NEVER promote the ICS (or any other article) "for the poor", as this will work VERY counterproductive in the general acceptance by the public. It is the wealthier and intelligent people who should use the ICS for economic and efficiency reasons. Other people will follow or copy the behaviour of the more advanced people from their society, not the poorest. The newly introduced article will then sell itself.

Limit Subsidy to Entrepreneurs
The NGO or development agent should not subsidise consumer products, but only support the demonstration process. From the very onset, collaboration needs to be sought with local entrepreneurs and distribution channels to be involved in the manufacturing and marketing. The manufacturer, entrepreneur or sales outlet can be supported with the supply of free user or installation manuals, advertisement, credit in the form of supplies, training, etc.

Reasoning Behind the Chosen Methodology
Community-based promotion and dissemination allows maximum involvement and communication with the target group in the decision-making process. This is important for replication and sustainability reasons. In reality, it is always the most advanced citizens in each village who are followed by others in the application of new technologies.

It is necessary that the villagers pay a real price for the equipment so they make a financial investment and take better care of the equipment. Also their household economy will indicate whether or not the financial investment is worthwhile and if the return on that investment is cost-efficient or rapid. The total elimination of any entrepreneur subsidy will need to be achieved within a few months when production increases.

Because the first targeted people are the tsunami victims in the new houses, many expect that the TOP-ICS will be supplied free of charge. To avoid such a start, entrepreneurs must be involved right from the beginning. The limited production capacity of the local entrepreneurs will limit the first distribution cycles to re-housed tsunami people only. With an increased production capacity, the overall cost will reduce and supply can be extended to other villagers under a zero-subsidy scheme.

[6] In one case, the household was from a very low caste; hence, the higher (wealthier) caste did not want to visit the house. Because this higher caste did not apply the technology, others also ignored the innovative design.

6. ENTERPRISE DEVELOPMENT

The TOP-ICS needs to be marketed through locally existing networks, such as hardware stores, firewood suppliers, market places and mobile traders.

Contracting and Subcontracting
The initial series of TOP-ICS's can be contracted to the pottery manufacturers on the basis of the drawings provided. Good quality control on design, measurements and functioning is required. For contracting in an illiterate or semi-illiterate environment, the production of a small series of approved prototypes is necessary. The approved prototypes can be used as demonstration models and then left with the contracted entrepreneurs to copy.

Jigs for Series Production
For series manufacturing of the metal component, jigs should be made, especially for cutting, folding and welding. The jigs will assist in ensuring all components are cut to the same length and welded correctly. Although some initial investment will be necessary for making the jigs, the cost can be quickly recovered owing to the improved working method.

Cost Reductions with Improved Efficiency
The overall manufacturing cost price of a product is approximately halved when the production is 100-fold. For example, the TOP-ICS would cost LKR 500 if made one at a time, excluding the one-by-one distribution. The same TOP-ICS can be made at about LKR 250 if 100 units are manufactured and sold at once.

An NGO should preferably not be involved in the production and sales of the consumer product, but rather support the development of the local entrepreneur. This is to avoid market price distortion by the NGO when it does not include all their administrative and overhead costs as part of the consumer price. Some NGOs also want to subsidise the consumer product. Such action will almost guarantee that the product never becomes a sustainable article and accepted as a consumer product.

Financial Monitoring by NGO
In order to assess if the production is profitable, good bookkeeping is required of the material costs, subcontracts, operation, and distribution expenses. When the production and employed staff increases, good financial records need to be kept of contracts. Contracting staff or production should preferably be done per produced unit, rather than on a salary basis. Precise quality control is necessary.

Entrepreneur Support
The following steps in the development process can be realised by an NGO:

a) Capacity building of the local staff in the general ICS technology through study of relevant documents and Internet information available.
b) Manufacturing of several prototype ICS's, considering locally available materials, local manufacturing techniques, current use of cooking equipment and habits among the target population. The development of the prototypes will go through several phases of manufacturing, field testing, efficiency measurement and manufacturing with adjustments.
c) Develop promotional material and translate into local languages and picture stories.
d) Place new models in villages with interested (motivated) families who normally collect firewood for all their cooking needs.
e) Realise promotion with the users in the villages and develop a marketing network. Involve current users in the distribution network and establish commission and re-sale mechanisms. Collect orders and coordinate production and delivery through local entrepreneurs.
f) Develop, in coordination with entrepreneurs, local sales outlets and distribution networks through commercial service providers and contractors, linking them to the manufacturers.

g) Ensure quality control during the production process and reduce manufacturing costs.
h) Enhance financial turnover with the entrepreneurs to include other cooking-related items, such as pots and pans, pressure cookers, etc.
i) Invite colleagues from other NGOs to partake in the promotion activity and provide them with the promotional material and marketing network.
j) Invite colleagues from other districts in the country to explain the technology, production and dissemination process, advantages, bottlenecks and solutions. Provide them with the technical and financial details for local replication.

7. GENERAL ICS ASPECTS

Overall Aspect
The ICS improves the living circumstances (after the tsunami) and household economy of rural families using firewood as cooking fuel.

Specific Aspect
Market-based dissemination of several models of ICS's (fixed and mobile) saves about 50% firewood and 50% in time required of women for collection of firewood and cooking.

Socio-Economic Aspects
Use of the ICS reduces:

- ✓ The demand for firewood and biomass fuel.
- ✓ Carbon emissions caused by inefficient cooking stoves.
- ✓ Household expenses due to reduced need to purchase fuel.

The development of small enterprises in the manufacturing and dissemination process provides income generation and livelihood, essential components in the general rehabilitation process after the tsunami.

All low-income families in Sri Lanka still use firewood for their basic cooking needs. The estimated number of firewood users is probably one quarter of the entire population or 1,000,000 households. Time saved (by women) can be invested in more productive activities or in improved healthcare and quality childcare. International research on ICS's and time management indicates that primarily women tend to savour the free time, improve their social relationships in the village and spend more quality time with the children. Eventually some time can be spent on learning (studying) and income-generation activities.

The direct result of reduced firewood consumption and improved burning efficiency is a decrease in smoke emissions by at least 80%. This will have a positive affect on women's health, reduce respiratory diseases and improve overall resistance to other diseases. Further improvement of the chimney and hood area may further reduce smoke hazards.

Technical and Environmental Aspects

(1) Reduction of 50% of the biomass or fuel needed for cooking.
Fewer people will switch to kerosene, hence saving fossil fuel. One TOP-ICS saves approximately 500 kg firewood/year. When the ICS is used instead of a kerosene gasifier, the equivalent of minimal 100-150 litres of kerosene is saved per year per family (2-3 litre/week). This amounts to minimal 100 million litres of kerosene (or liquid gas) per year for the whole of Sri Lanka. With increasing fuel prices, this becomes an important sum in foreign currency savings on importation.

(2) Substantial reduction in carbon emissions.
Less cooking fuel requirements signifies an equal reduction in carbon gas emissions. These gases consist of CH_4 (Methane), CO_2 (Carbon Dioxide) and some other poisonous gases, such as formaldehyde. One TOP-ICS saves about 500 kg firewood/year, about half of which consists of carbon. For every 4000 TOP-ICS used, about 1000 tons of CO_2 is reduced annually. In theory, considerable international payments can be obtained when ICS's are accepted for carbon trading under the Kyoto Protocol. Current trading price is around USD 10/ton CO_2 equivalent saved.

Resume

The TOP-ICS is linked to the following development aspects:

a) Environment, with the reduction of the domestic energy needs in firewood and kerosene.
b) Environment, with the conservation of biomass and reduction of smoke and carbon emissions.
c) Gender, with the improvement of time management of women and girls.
d) Gender, with the reduction of diseases among women and children due to less smoke.
e) Poverty alleviation, due to a reduction in expenses incurred for firewood and kerosene purchase, especially for the lowest income groups.
f) Poverty alleviation, with the possibility of enhanced education for women.
g) Poverty alleviation, with income generation through development of small enterprise or employment in another economic activity.
h) Reduced monetary expenses for the country, related to the importation of non-renewable fuels, such as kerosene and LPG.
i) Empowerment, through the use of the available time in community management.
j) Capacity building of social animators, entrepreneurs and NGO staff during the dissemination process of the TOP-ICS to the villages.
k) Capacity building of small entrepreneurs in product manufacturing, quality control and marketing of new products.

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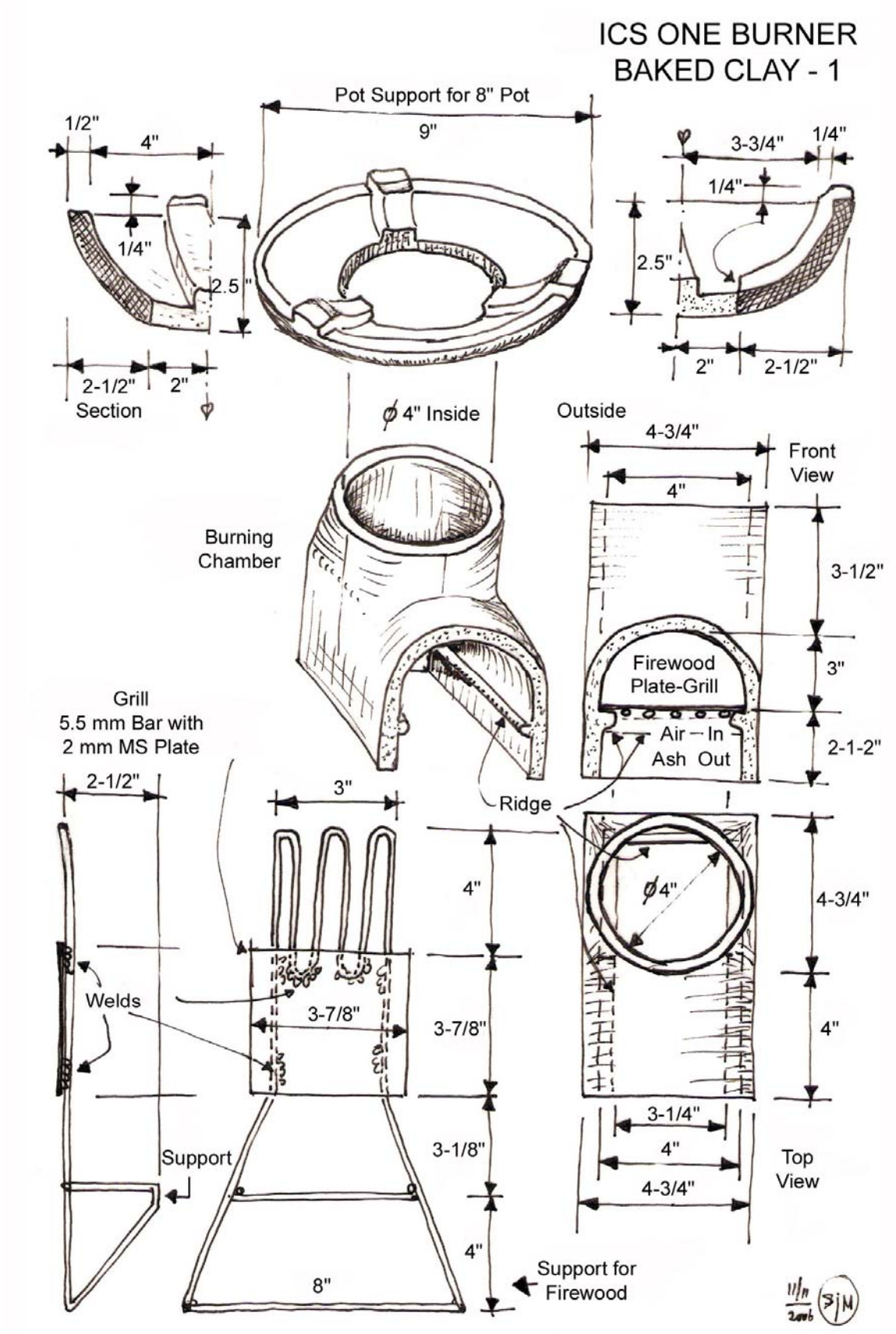
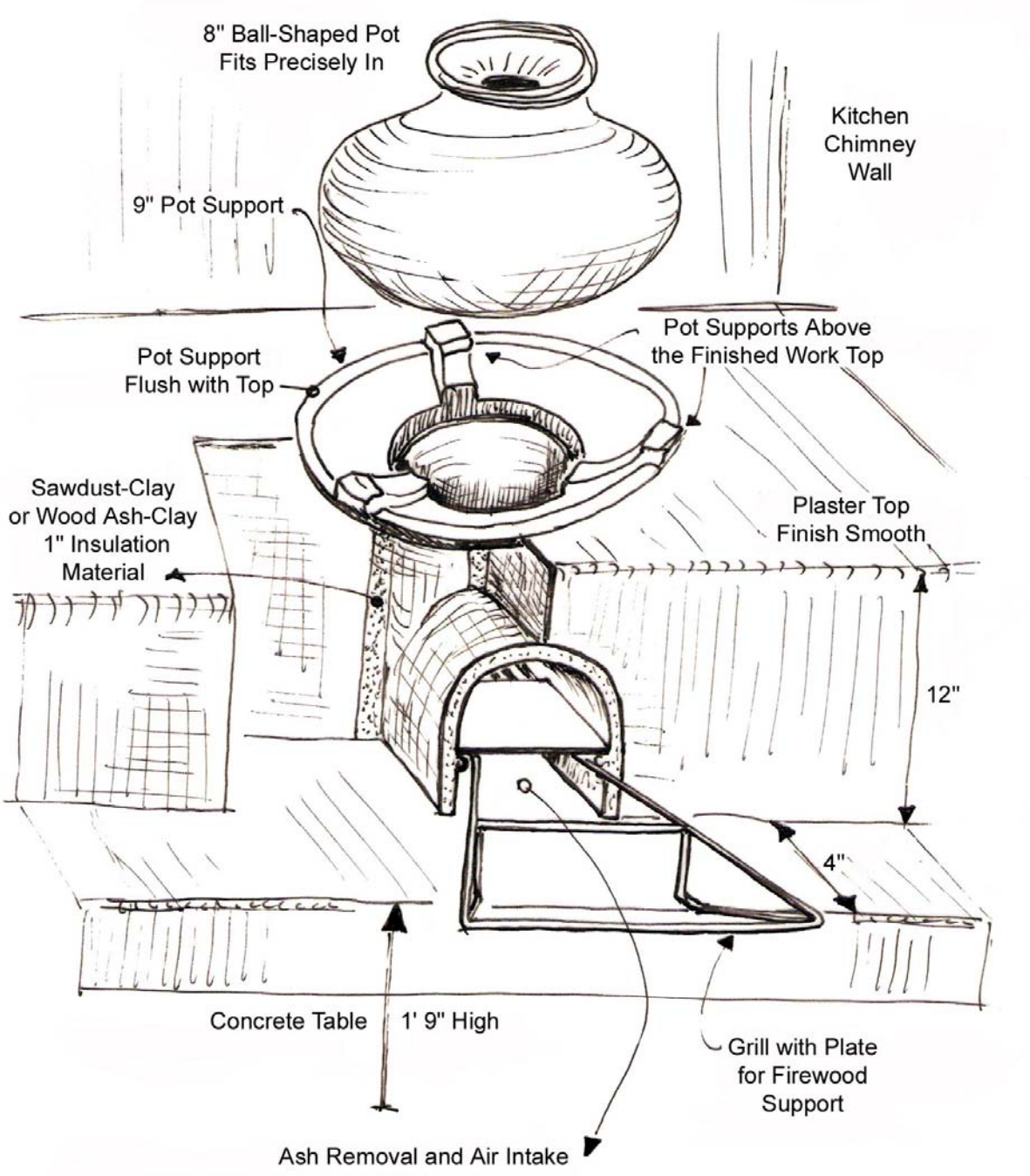
ANNEXE I

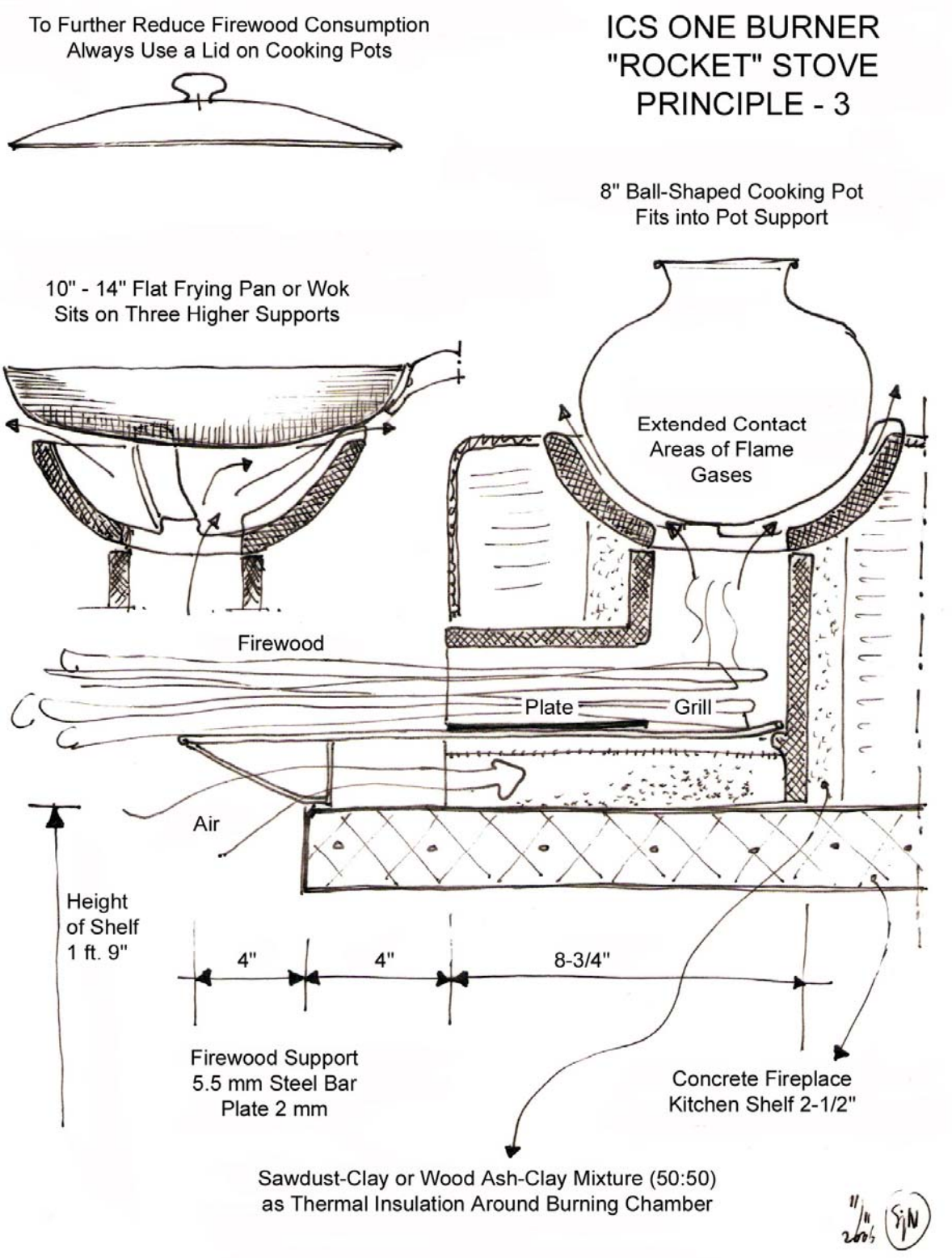

ICS ONE BURNER
BAKED CLAY - 1
Pot Support for 8" Pot
9"
1/2"
4"
1/4"
2.5"
2-1/2"
2"
Section
3-3/4"
1/4"
1/4"
2.5"
2"
2-1/2"
ϕ 4" Inside
Outside
Burning
Chamber
4-3/4"
4"
Front
View
3-1/2"
3"
Firewood
Plate-Grill
Air – In
Ash Out
2-1-2"
Grill
5.5 mm Bar with
2 mm MS Plate
2-1/2"
3"
Ridge
4"
3-7/8"
3-7/8"
Welds
3-1/8"
Support
4"
8"
Support for
Firewood
ϕ4"
4-3/4"
4"
3-1/4"
4"
4-3/4"
Top
View

ICS ONE BURNER INSTALLATION - 2



IMPORTANT:
The cooking pot should fit the pot support precisely,
allowing only a small gap between the pot and pot support.
Depending on existing cooking pots,
a 10" pot support for a 9" ball-shaped pot can be used.

ICS ONE BURNER "ROCKET" STOVE PRINCIPLE - 3



ANNEXE II

Water Boiling Test for the TOP-ICS							**November 2006**
Scale Precision is 10 gram. Use lightweight aluminium pot for simple calculation (without including a and n into the calculation).							
#	Description	Test 1	Values	Test 2	Test 3	Test 4	Test 5
a	Weight of cooking pot. With a lightweight aluminium cooking pot this value can be ignored.		kg				
b	Weight of water in the cooking pot. Fresh water is 1 kg / litre =1000 cm^3.		kg				
c	Temperature of cold water in pot.		degrees Celsius				
d	Temperature of boiling water in pot. At sea level, for fresh water this is 100 degrees Celsius.	100	degrees Celsius	100	100	100	100
e	Mass of evaporated water. To measure this, weigh the water again and calculate the difference with the precise weight of b.		kg				
f	Weight of dry firewood or biomass (palm leaves, coconut husks etc).		kg				
Once the water boils, the fire needs to be extinguished by removing the firewood and the remaining charcoal. Both biomass and charcoal need to be weighted separately.							
g	Weight of all the charcoal. Include the charcoal from wood ends, the burning chamber and below the grill.		kg				
h	Weight of the remaining firewood without the charcoal.		kg				
i	Caloric value of dry wood.	16,500	kj/kg				
j	Caloric value of dry charcoal.	28,500	kj/kg				
k	Specific heat of water.	4.2	kj/degree Celsius				
l	Specific heat of vapour.	2,256	kj/degree Celsius				
m	Specific heat of pot. With a lightweight aluminium cooking pot this value can be ignored.		kj/degree Celsius				
n	Energy output related to pot = (m) x (a) (100-c)		kjoule				
Energy input = 16,500 x (f - h) - 28,500 (g)			kjoule				
Energy output = 4.2 x (100 - c) + 2,256 (e)			kjoule				
Efficiency = output (water +pot) : input			%				
		Date:		Date:	Date:	Date:	Date:
Person realising the test:							