Rocket Stove Training Manual

Climate change Adaptation Sustainability Awareness

sazaniassociates

Contents

Acknowledgements

The manual was prepared during the training of local metal workers and metal work students at the Mkokotoni Skills Centre, of the Zanzibar Vocational Training Authority, Ministry of Education and Vocational Training Zanzibar.

The training was provided by Jason Morenikeji of the Clean Energy Company, Mozambique, www.tcei.info and was funded by the Welsh Government and Comic Relief as part of Sazani Associates CASA (Climate change Adaptation Sustainability awareness) project in Zanzibar.

Introduction

This manual details how to produce a rocket stove. Its design has been optimized through insights into local routines, cooking rituals, networks and socio-cultural dynamics in northern Zanzibar. This included the traditions and practicalities of local firewood gathers, metalwork Fundis and cooks.

Sazani Associates trials found that the rocket stoves use 40% less wood than the traditional (open) 3-stone fire stove. This may change as users develop the skills to use the stoves and research elsewhere points to firewood savings of 50/60% over the traditional (open) 3-stone stove (source: MEMD – EAP: Institutional rocket stove end-users impact survey, April 2007).

This implies that the amount of firewood used by a family in one day with a traditional 3-stone fire can be used for 2 – 3 days with the rocket stove.

The stoves are easy to make by any competent metalwork Fundi. The investment in a rocket stove can be recovered in a short time through money save as a result of firewood savings. The knowledge of making these types of stoves can help people start their own business and increase their skills as Fundis.

What is a Rocket Stove?

The Rocket Stove is a clean burning and fuel-efficient cooking stove which can use thin sticks as fuel. This means that Rocket Stoves are more efficient than open fires; they use less firewood therefore reduce long-term household expenditure. The Rocket Stove's ability to use small dried branches negates the need to rely on charcoal and deforestation with its increasingly destructive environmental impact.

Rocket stoves have an insulated combustion chamber which allows them to focus the heat where it is needed during the cooking process (i.e. into the cooking pot). The insulation also makes it safer to touch during and after use.

Rocket stoves make cooking with fire easier, safer and faster than with open fires. They are quicker to start, needs little tending, and can meet the specific needs of domestic and small/large scale commercial cooks. Rocket Stoves reduce the time taken to start a stove and the time to cook/boil food due their excellent fuel efficiency. A user does not have to blow air into the stove to fan the flame. Once lit, the stove fire will burn continuously unless one stops putting firewood into the stove. When compared to a 3-stone open fire, the rocket stoves cook a given quantity of food in half the time.

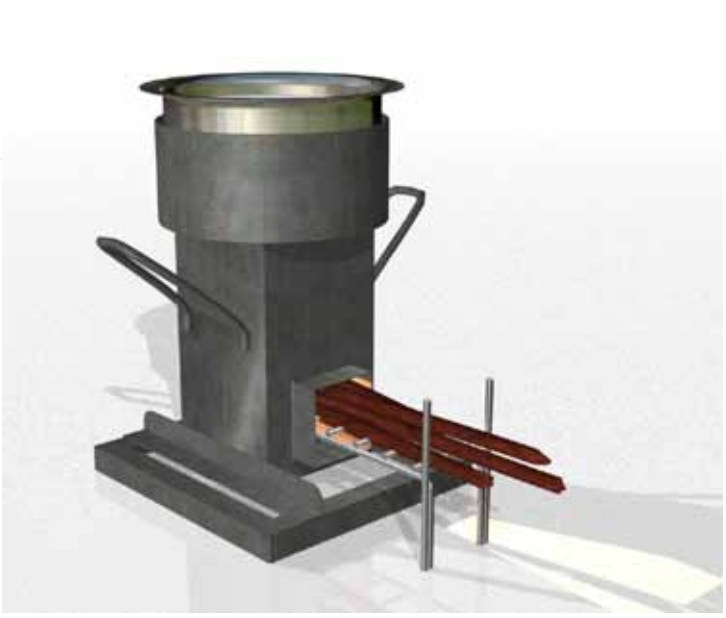


Illustration of the rocket stove in use – with 39cm cooking pot (Source: TCEI)

Why Rocket Stoves are good

Rocket Stoves are ideal for domestic and commercial cooking and water heating purposes in many locations across – not only Zanzibar, but East Africa as a whole - where wood fuel is expensive and/or difficult to find. The firewood wood is burnt inside the rocket stove's insulated high-temperature combustion chamber (see below). A simple 'elbow' shape is used to enable a good air flow and the controlled use of firewood resulting in the full combustion (including the harmful smoke) and efficient use of the resultant heat.

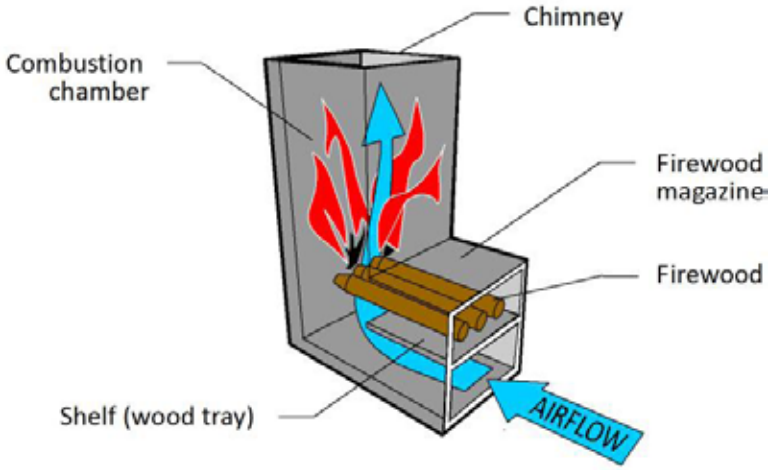


Illustration of the 'elbow' configuration of the Rocket Stove (Source: TECI)

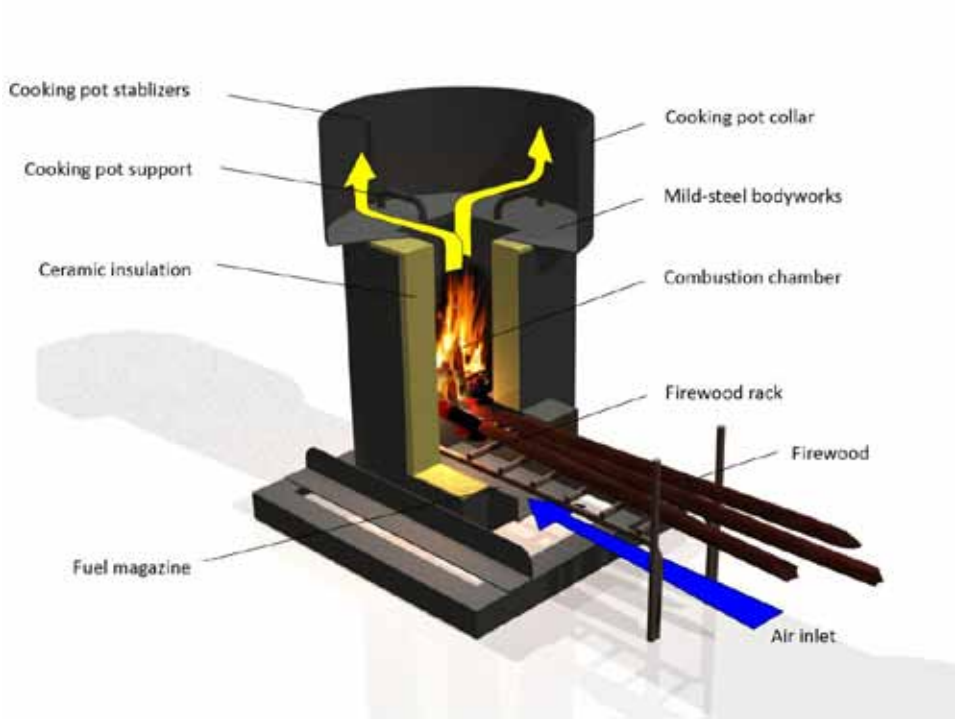
A rocket stove's main components are:

Firewood magazine: Into which the unburned fuel is placed.

Combustion Chamber: Where wood is burned and provision of updraft to maintain the fire.

Chimney: Where waste heat and smoke is expelled.

Rocket Stoves are able to achieve a very high degree of heat transfer to the cooking pot because the stove's cooking pot collar channels the heat from the firewood directly to the surface area of the cooking pot. By using less firewood these stoves reduce firewood expenses and environmental impacts.



'Cut-away section' illustration of the 'elbow' configuration, air inlet (blue) and heat flow (yellow): (Source: TECI)

Rocket Stove theory

An open fire (3-stone fire) is often 90% efficient at the work of turning wood into heat. But only a small proportion, from 10% to 40%, of the released energy makes it into the pot.

Heat transfer can be increased by directing the heat in a narrow channel parallel to the cooking pot surface, this feature is referred to as a collar.

Key Feature:	**Description:**
Air inlet and air flow:	Increasing the flow of the right amount of air helps the fire burn hotter and helps to improve the burring of the firewood. By rising the burning firewood up off the ground allows air to pass under the firewood thereby improving the quality of the fire. The opening into the fire (fuel magazine), the size of the spaces within the stove through which hot air flows, and the chimney should all approximately be the same size (i.e. constant cross sectional area). As the firewood burns within the combustion chamber air is drawn into the combustion chamber. This will help to maintain a good draft throughout the rocket stove keeping the fire hot. The right amount of incoming air helps the fire burn cleanly.
Cook pot collar:	For cooking purposes the Rocket Stove design keeps the cooking pot in contact with the fire over the largest possible surface area to improve the efficiency of the stove. Although the collar will limit the rocket stove to one size of pot. The cooking pot collar is used to create a narrow channel which forces hot fire air to flow along the bottom and sides of the cooking pot.

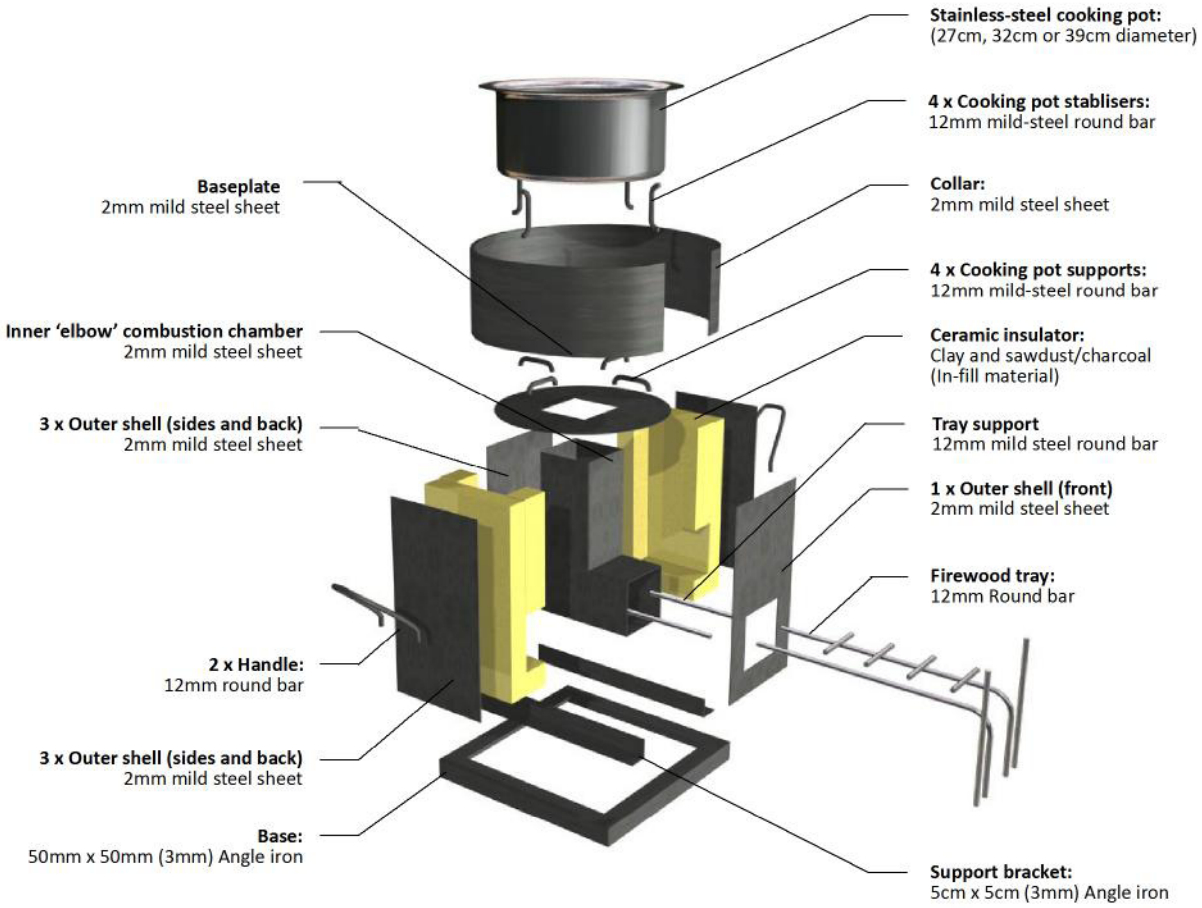
What are the Key Benefits of a Rocket Stove?

- **Attractive Business Model:** Rocket stoves are easily fabricated, maintained and easy to use. They demonstrate obvious financial incentive for a low-income cook concerned about the cost of firewood and charcoal. The promotion of Rocket Stoves through local networks has the potential to create sustainable small businesses for local metalwork Fundis and micro entrepreneurs.
- **Environmental Impact:** The design of Rocket Stove allows it to operate on about 50-70% less firewood as a traditional (3-stone) open fire. It can also use smaller diameter firewood making it ideal for use on Zanzibar Island for both domestic and commercial usage. These stoves use less firewood leading to a reduction in deforestation.
- **Improved Efficiency:** The design of the Rocket Stove enables approximately 80% of the heat from the stove to enter the cooking pot. With a traditional 3-stone fire only 10% to 40% of the released heat makes it into the pot. By improving the heat transfer from the wood to the cooking pot will save significant amounts of firewood and ultimately reduce the overall cost of firewood.
- **Improved health:** The Rocket Stove's insulated high-temperature combustion chamber ensures the firewood is fully combusted; this includes harmful smoke emissions (particulate matter) and reduced Carbon Monoxide (CO) emissions offering a cleaner environment for both women and children. The rocket stoves hardly produce any smoke. A bit of smoke is produced only when lighting the fire. (Note: The stove will also produce some smoke if wet firewood is used). No more tears or smoke saturated clothes.

Fabrication

The size of the stove is determined using the size of the saucepan that will be used for cooking in it. The saucepan capacity is therefore the first thing that should be determined. This manual details the dimensions for 3 sizes for cooking pots around which the stove will be based. For bigger cooking pots the sizes can be adjusted accordingly.

Fabrication Process:



An exploded illustration showing the general arrangement of the TCEI-Rocket Stove

Metalwork

Metal fabrication tools necessary:

Workshop tool:	Tasks:
Hacksaw	Cutting piping and metal bar
Arc welding	Joining metal pieces
Welding rods	Welding
Pick hammer	Removes slag from welded metal parts
Angle grinder – cleaning disc	Smoothening the welded joints
Angle grinder – cutting disc	Cutting sheet metal
Wire brush	Cleaning metal surfaces prior to welding
Measuring Tape	Taking linear measurements
Vice Holding	Material support
Hammer	Bending metal bar and metal sheet.
Driving chisel	Cutting metal sheet
File	Smoothing metal edges
Compass	Drawing circles
Try Square	Confirming right-angled corners
Anvil (or equivalent)	Platform for hammering

Metal fabrication material necessary:

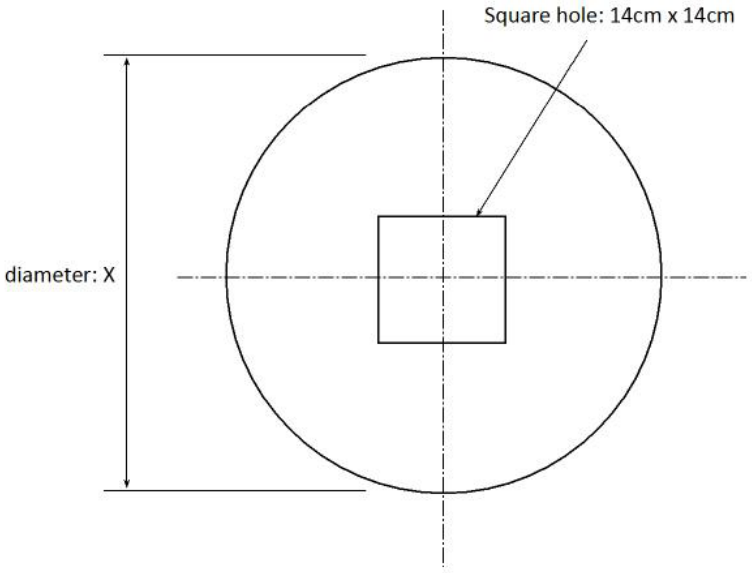
The Rocket Stove can be fabricated from widely available and standardized metal sheeting, angle iron, bar and/or tubing.

Workshop material:	Specifications	Quantities:
2.0mm mild-steel sheet	1.5m x 2.4m	One sheet
Angle bar	50mm x 50mm x 3mm	One length (6m)
Round bar 12mm diameter	12mm	One length (6m)

Fabrication Process

Base plate (A2): The circular base-plate (A2) forms the base of the cooking pot collar (A1). See exploded diagram. In the centre of the base plate a 14cm x 14cm square hole is cut from the centre using an angle grinder or hammer and chisel.

Cook pot size:	27cm	32cm	39cm
Diameter X of base-plate (2mm mild steel):	31cm	36cm	43cm



Collar (A1): The collar houses the cooking pot during cooking and ensures the heat is channelled into the cooking pot. It is made of 2mm mild steel metal rectangle formed into in a cylinder. Use an angle grinder with a metal cutting disc to cut sheet metal. Alternatively the metal sheets could be cut with a hammer chisel.

If the appropriate size metal sheeting is not available weld two or three off-cuts together.

Cook pot size:	27cm	32cm	39cm
Size of: 2mm mild steel:	14.0cm x 98.5cm	16.0cm x 114.0cm	18.0cm x 136.0cm

Photo showing the bending of the collar (A1).

Bend the cooking pot collar as shown above.

The base-plate (A2) can be used as a guide as the collar is welded in place.

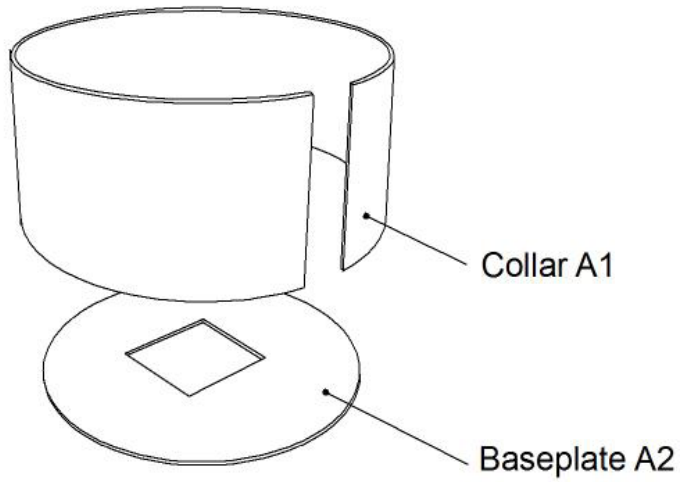


Illustration showing the position of the collar and base-plate before welding (Source: TCEI).

Photo showing the joining of the collar to fit the base-plate

Photo showing the welding of the base-plate to the collar

Photo showing the joining of the collar with the base-plate

Cooking pot stabilizers and support brackets

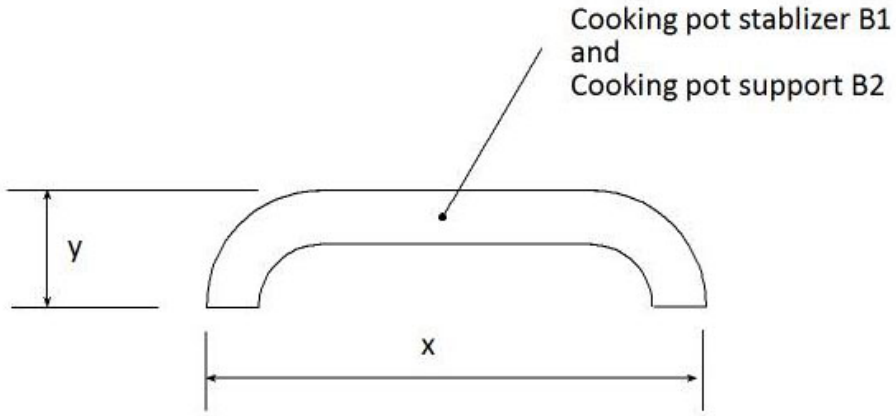
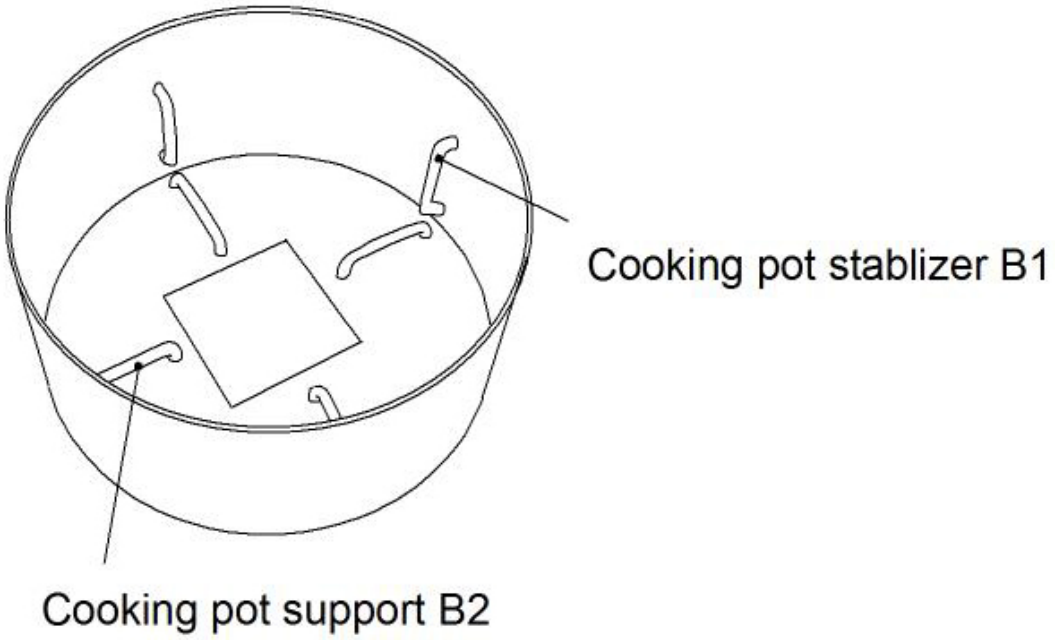


Illustration of cooking pot support/stabilizer

Cook pot size:	**27cm**	**32cm**	**39cm**
Stabilizer: Distance y (12mm round bar):	2.0cm	2.0cm	2.0cm
Stabiliser: Distance x (12mm round bar):	6.0cm	7.0cm	8.0cm
Support: Distance y (12mm round bar):	3.5cm	3.5cm	3.5cm
Support: Distance x (12mm round bar):	6.0cm	8.0cm	10.0cm

Photos showing the bending of the support brackets using a hammer and vice

Lightly weld the 4 x supports and 4 x stabilizers are shown below:



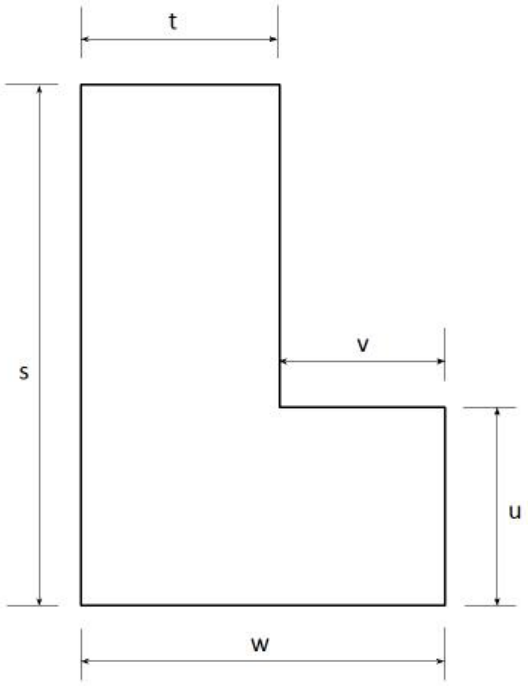
Photograph showing the cooking pot supports and handles in position

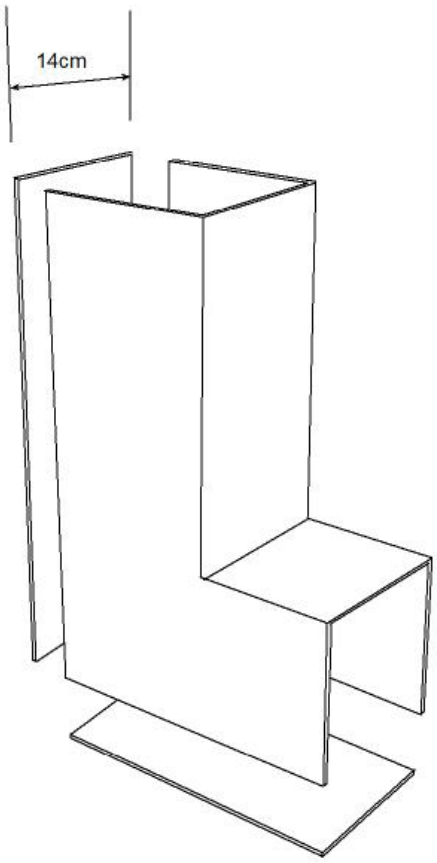
With the stabilisers lightly welded in place, test the cooking pot inside the collar to confirm that the cooking pot can slide in and out of the stove without difficulty.

The Elbow (Combustion chamber and Firewood magazine)

Cut and weld the rocket stove's elbow as illustrated below:

Cooking pot size:	27cm	32cm	39cm
Distance: s	35.0cm	42.0cm	42.0cm
Distance: t	14.0cm	14.0cm	14.0cm
Distance: u	14.0cm	14.0cm	14.0cm
Distance: v	8.0cm	10.0cm	12.0cm
Distance: w	22.0cm	24.0cm	26.0cm



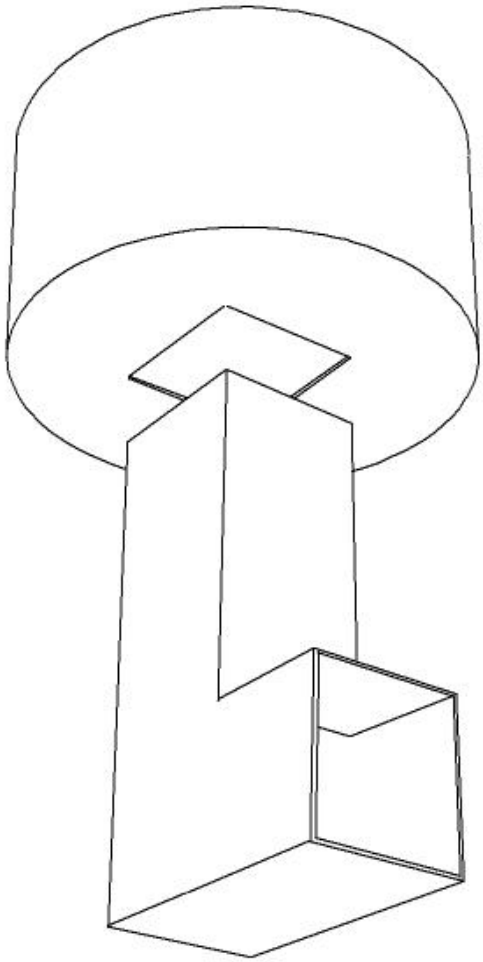


Photos showing the welding of the 'elbow' shaped combustion chamber.

Note: The characteristics of the rocket stove can be adapted to suit the application. Taller elbows produce less smoke but are slightly less efficient - due to the greater distance between the pot and the radiant heat of the firewood and the higher losses into the stove body. Shorter elbows produce more smoke but have greater heat transfer due to the closer proximity of the pot to the radiant firewood.

Cut and weld the rocket stove's elbow as illustrated below:

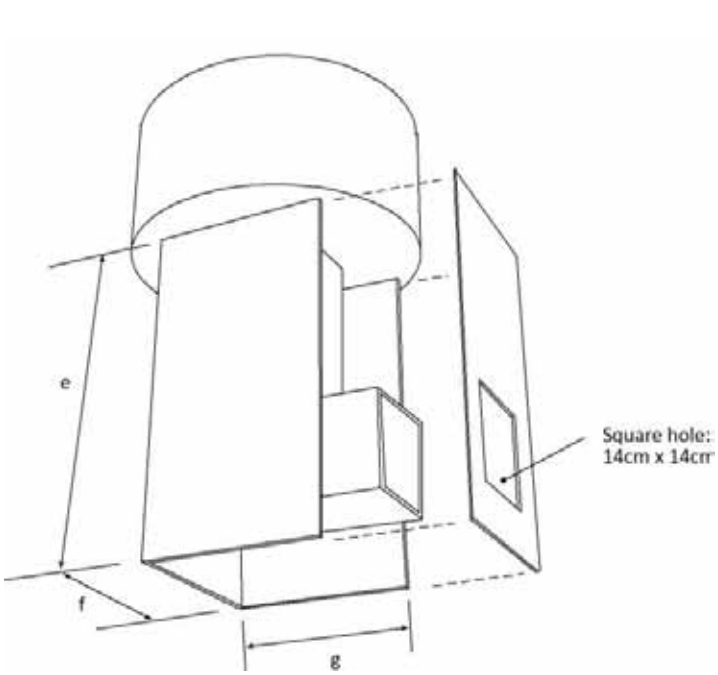
Weld the 'elbow' to the base-plate as shown in the illustration below:



Outer casing

Using 2mm sheet steel, weld an outer casing around the 'elbow' as shown below.

Outer Casing box size:	27cm	32cm	39cm
Distance: e	39.0cm	40.0cm	42.0cm
Distance: f	21.0cm	24.0cm	26.0cm
Distance: g	21.0cm	24.0cm	26.0cm



An illustration and photograph showing the outer casing assembly.

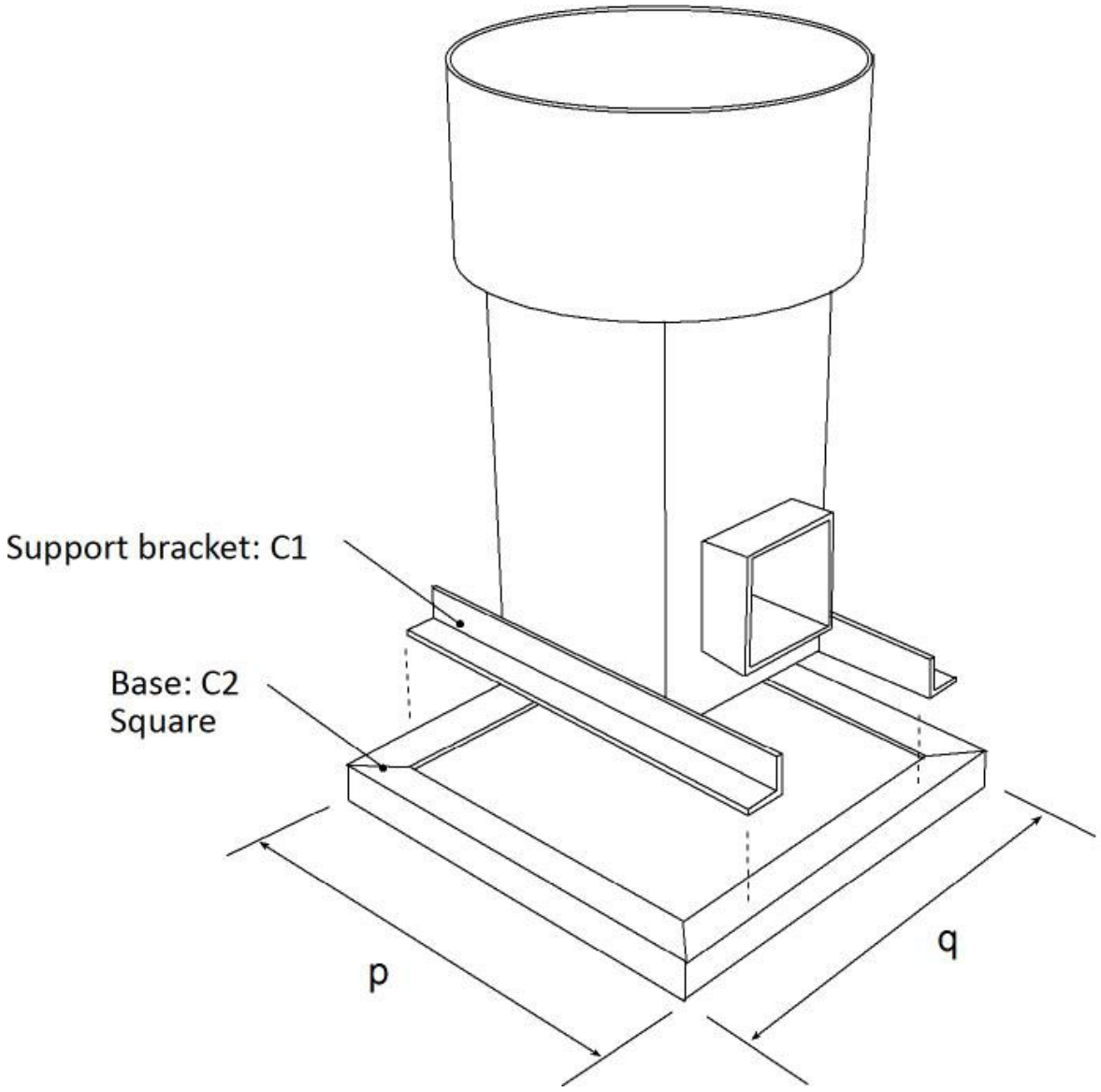
Side support brackets and Base

To ensure the rocket stove is stable, a heavy and wide base is used. Using 50cm x 50cm angle iron, cut 4 length of size 'q' and 2 lengths of size 'p'. Weld the 2 side 'Support Brackets' (C1) to the body of the rocket stove. Weld the remaining 4 lengths to fabricate the square Base (C2). As shown below:

A photograph showing the base assembly before mounting

Base and brackets:	27cm	32cm	39cm
Distance: p	40.0cm	45.0cm	50.0cm
Distance: q	40.0cm	45.0cm	50.0cm

Weld the base and the support brackets to the main body of the rocket stove (as shown below).



Handles

Use 12 mm diameter round bar to make the 2 handles. The handles can be bent to suit preferences. Each handle is made from approximately 60cm of round bar.

Measuring the handles before welding

Tray Rack

Cut 2 lengths of 12mm bar (C4) and weld as shown below:

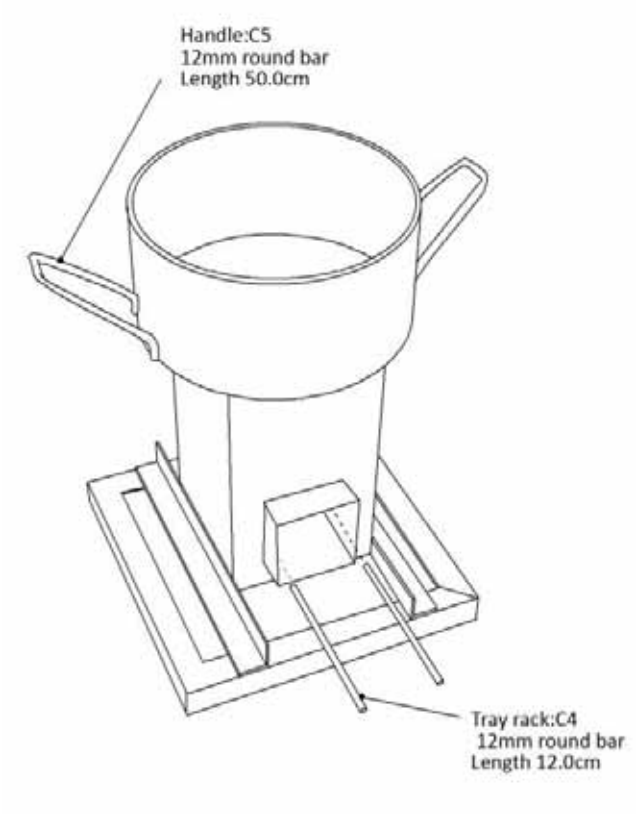


Illustration showing the handles and tray support bars

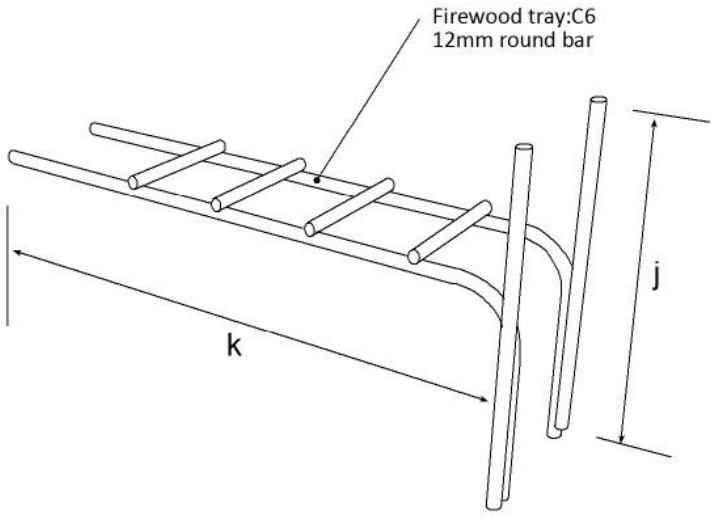
Firewood tray

To ensure the fuel is burnt efficiently in the rocket stove a tray/rack is used. The tray is not welded to the rocket stove. This is so that it can be removed to allow easy cleaning.

The design is shown below:

A photo showing the firewood tray in position

Firewood tray:	**27cm**	**32cm**	**39cm**
Distance: j	30.0cm	30.0cm	30.0cm
Distance: k	40.0cm	45.0cm	50.0cm



An illustration showing the firewood tray (Source: TCEI)

Ceramic insulation material

The insulation around the fire (combustion chamber) helps it burn hotter which will help to reduce smoke and other gasses which are harmful to people. Insulation should be light and full of small pockets of air such as lightweight ceramic brick, tiles or in-fill materials.

> **Note:** Natural examples of insulation material include pumice rock, vermiculite (a lightweight, cheap, fireproof material produced from natural mineral deposits in many parts of the world) and perlite.

Insulation material can be made by using river-bed clay mixed with sawdust and/or charcoal that can be burned off at a later stage in a simple kiln or wood fire. The burnt (fired) clay is resistant to cracking at high temperatures. This process leaves air-holes in the clay that are good for retaining heat and therefore improving the stove's efficiency.

> **Note:** Do not use heavy materials like sand or cement (as they remove heat from the fire).

Workshop tool:	**Tasks:**
Plastic sheeting	Mixing/protective surface.
Buckets	Transportation and measuring (clay, sawdust and water).
Shovel or Spade	Digging.
Bucket	Carrying water.
Hoe	Mixing ingredients, digging pit kiln.
Firewood	Firing the kiln.

Ceramic material fabrication materials:

Below are 3 suggested options for the ceramic insulation material:

Options:	**Mixture volumes/ratios:**	
a	1 bucket of river-bed clay	6 bucket of fine sawdust
b	1 bucket of river-bed clay	6 bucket of ground charcoal
c	1 bucket of river-bed clay	3 buckets of charcoal and 3 buckets of sawdust

Ceramic insulation material:

Photo showing the clay and charcoal before mixing

Photo showing the hand-mixing of clay and sawdust

Photo showing the mixing by foot of clay, charcoal and sawdust

Photo showing the filling of the cavity around the 'elbow'

Firing the kiln

To fire the clay and burn away the charcoal and sawdust, build a shallow pit. The size should be adequate to hold the Rocket Stoves and firewood. The pit can be brick-lined for improved heat retention (as shown below). The ceramic in-fill material – once packed into the rocket stove - should be left to dry in the sun for 5-7 days before firing.

A photo showing the (1m width x 1m length and 0.7m depth) brick-lined kiln

A photo showing the lighting of the kiln

A photo showing the TCE1-Rocket Stoves after firing

Post-fabrication finishing

- Grind all sharp edges of the metallic stove body to make it smooth.
- Clean the metallic stove body with a wire brush to remove dirt and rust.
- Paint the stove to protect the steel body from rust etc.

Using the rocket stove

Lighting the stove takes some practice but is straightforward once mastered. Ensure the firewood-tray is in place – this acts as a grate under the fire.

Do not put the sticks on the floor of the combustion chamber because air needs to pass under the burning sticks, up through the firewood and into the fire.

It is best to have the firewood close together and flat on the shelf, with an air space in between each stick. It is not necessary to jam the mouth of the fuel magazine full of wood.

The wood of the tray can be easily lit from below (at the back of the air-gap) using kindling.

Once the fire has started do not feed more firewood into the air-gap.

As the tips of the firewood is burnt the wood can be pushed into the fuel chamber to maintain an efficient fire. This process ensures there is clean and efficient combustion process.

Written and prepared by

Manual prepared by Sazani Associates in conjunction with Jason Morenikeji, The Clean Energy Initiative (TCEI)

CASA (Climate Change Adaption, Sustainably Aware) is a Sazani Associates initiative:

sazaniassociates

www.sazaniassociates.org.uk

The Clean Energy Initiative (TCEI)

TCEI is the development programme of the:

TCEC THE CLEAN ENERGY COMPANY

www.tcei.info

07th June 2012

Disclaimer

Relative to the traditional 3-stone (open) fire place the firewood institutional rocket stoves are believed to offer significant benefits to the user - including firewood savings, reduced time for cooking and reduced indoor air pollution. This stove construction manual is believed to be a useful tool for instruction in the procedure for the construction of the TCEI-rocket Stove. Sazani Associates and The Clean Energy Company do not assume responsibility for the completeness or usefulness of the information herein.

Sazani Associates and The Clean Energy Company will not assume liability in respect of any claim(s) that may arise in the event of any injuries and / or damages that may occur during the fabrication, use, maintenance of the TECI-Rocket Stove's design or procedure described herein.

Sazani Associates
33 Quay Street
Carmarthen
Carmarthenshire
Wales, UK
SA31 3JL

Tel: (01267) 243176
Email: info@sazaniassociates.org.uk
Web: www.sazaniassociates.org.uk

thewaterloofoundation

UKaid from the Department for International Development

CASA Initiative

COMIC RELIEF

Noddir gan Lywodraeth Cymru
Sponsored by Welsh Government