



FUEL FROM THE FIELDS

making charcoal briquettes from bio-waste

an AmahaWe Uganda project

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making fuel briquettes

1 - What are Fuel Briquettes?

Fuel Briquettes are balls or pellets of compressed natural materials that can be burnt for cooking instead of firewood or wood-charcoal.

'*Fuel From the Fields*' means making Fuel Briquettes from materials including recycled litter, garden waste and agricultural waste.

These materials can be carbonised, processed, shredded, mixed, soaked, pulped, compressed and dried to create one of **the simplest, cheapest and most efficient** types of cooking & heating fuel on the market.



Why use Fuel From the Fields?

It's estimated that more than 2 billion people worldwide live on less than \$2 per day.

Energy Poverty affects 95% of all Africa.

Over 60% of African families spend more money on cooking fuel than on education and food combined.

The cost of firewood and charcoal forces families to choose between paying for either cooking fuel or for food, school fees, medicine, etc.

Worldwide, the greatest use of trees and forests is as firewood.

A larger volume of wood is used for cooking than for construction timber, pulp, veneer and plywood **combined**.

The majority of people in rural and sub-urban Africa cook using timber on open fires.



Whilst cooking with firewood may seem practical in African countries that don't lack trees, it causes major problems for individuals, the local community and the continent:

- Cutting trees for firewood is not sustainable. The quantities required are huge. Uganda, Zambia, Tanzania & Kenya have lost over 50% of their trees in the last 35 years.
- Removing trees makes the soil less stable. Farming land and family gardens are more likely to be washed away or damaged by rainfall. This causes significant flooding risk and loss of life.
- Firewood is expensive to buy (due to transportation costs) and those people without access to transport, often spend many hours each day searching for timber.



Many people cook inside their accommodation, surrounded by carcinogenic woodsmoke & fumes.

Timber burns inefficiently. This increases both the cost and the time it takes to prepare food or boil water (prolonging the health risks even further)

More than 2 million African women and children die every year from diseases caused by woodsmoke.

That's 1 person every 15 seconds.

What are the advantages of briquettes?

Each tonne of charcoal requires cutting 80+ trees, while briquettes are made purely from waste.

Briquettes require less time, money, energy and risk than finding, cutting and transporting timber.

Briquettes produce approximately 60% less carcinogens than using timber as firewood.

Briquettes burn 50% more efficiently than wood

Briquette manufacture can be for personal use, or for selling locally to create an income.

The 2013 study commissioned by The European Union and The World Health Organisation concluded that:

*"Briquettes alone will not solve the major sustainability problems of wood fuel use in Africa. However, it is noted that **16%** of the continent's total wood consumption and up to **50%** of the charcoal trade could be replaced by briquettes from biomass waste."*

2 - Briquette Making, Step-by-Step;

Small chips of wood charcoal (fines) or charcoal dust can either be obtained from charcoal sellers, collected from the bottom of sacks after the charcoal pieces have been used, or produced locally by carbonising organic farm waste such as maize cobs, sugar cane waste or coffee husks in oil drums or kilns.

Once the charcoal dust has been collected, it is a quick and simple process to turn it into clean, efficient, cheap cooking fuel.

a) Preparing the Charcoal:

Crush the charcoal fines into small pieces.

This can be done either by using a closed sack and a stick, or by using a 'pestle & mortar'.



If using a pestle, sprinkle a little water onto the charcoal to stop charcoal dust from being breathed in.

The crushed charcoal can be collected in a basin and any larger lumps removed and re-crushed.

Charcoal lumps that are too big can be removed by using a medium-holed sieve or by shaking the basin so that the large pieces come to the top.

It is not necessary for the charcoal to be turned to dust, but it should be quite fine, similar to rice grains.



The crushed pieces should be inspected to make sure there are no pieces of plastic, glass, sharp metal amongst them - sharp pieces will be dangerous when making the briquettes by hand and plastic will produce poisonous fumes when burning.



b) Making the Binder:

The charcoal dust will need a binder to hold it together when it is shaped. Any sticky starch such as cassava, maize, banana or aloe can be made into a porridge and used as a binder.

Cassava or maize flour is simplest and can be bought from markets. However, high quality flour is not necessary. Waste flour can be collected at little cost from flour mills or packaging plants.

Alternately, if flour is not available, a cassava root can be finely grated into water to make the binder.

We have found that between 300 grammes to 500g of flour works well with 2 - 3 litres of water and 1 - 1.5 basins of crushed charcoal.

Experiment with the quantities of flour & water needed to make the best binder: thicker porridge will need more flour; thinner porridge will use less but may take a little longer for the briquettes to dry.



1) First, heat water to cook the porridge. Just like food porridge, the water should not be boiling.

If waste flour is to be used to make the porridge, sieve it to remove dirt, stones, lumps, etc.

2) Mix the cassava flour with **cold** water into a smooth paste in a bowl...



3) Then add the cold cassava paste from the bowl to the hot water on the fire...



4) Cook the flour paste into a porridge consistency.

This should not be as thick as nsima, pap or mielie-meal, but should be cooked until the porridge is sticky when tested between finger and thumb (a bit like honey).



c) Mixing:

1) Pour some of the cooked porridge into the basin of ground charcoal.



2) Mix the porridge into the charcoal with a spoon at first (the porridge is hot!).



3) After a couple of minutes the porridge and charcoal should be mixed thoroughly by hand.



4) Feeling the consistency of the mix by hand is the best way to understand the correct wetness and balance of porridge to charcoal.

If the mixture is too dry, a little cold water can be added.



If it is too wet, add more charcoal dust.



Only practice, and burning the briquettes after they have dried, will teach you the best mix of cassava flour, water and charcoal dust.

d) Moulding & Drying:

The simplest way to mould the briquettes is by hand.



For efficient burning, it is best if they are not too large, but a variety of different sizes can be useful when starting a fire or cooking different foods.

The ideal Fuel Briquette size is simply what can be moulded in the palm of a hand.



The balls of mix should be compressed firmly, but it is not necessary to use great force since no water will be squeezed out and the balls of charcoal and porridge binder will stick together as the binder dries.



Once the shape has been made and compressed the Fuel Briquettes must be handled carefully and dried thoroughly.



While they are wet, they are very fragile. They will become much stronger as they dry.

Therefore it is important that the briquette is handled or moved as little as possible.

The pressed briquettes should be dried in a warm place on either a sack...



...or something like a piece of old corrugated metal so that they can be moved into the sun or out of the rain as necessary **BUT** it is better if they can be left in one place until they are completely dry.



In a warm climate it will take around **3 - 5 days** for the Fuel Briquettes to dry well enough before they can be burned efficiently.

A variety of moulds can also be used to make the Fuel Briquettes. Hand moulding is easiest, but pots and cups can make a more regular shape.

The difficulty with moulds comes when removing the wet mix from the pot. This is when the briquette is most fragile and, if disturbed, will not dry in one piece. For example, yoghurt pots or cups can be lined with a plastic bag before filling...



Once pressed, stand on the ends of the bag and carefully pull up the pot...



Carefully remove the bag to leave a cone-shaped briquette.

e) Alternative Mould & Pressing Equipment:

Depending upon how many Fuel Briquettes are to be made, a variety of different moulds and pressing equipment is available or can be made simply.



A timber lever-press can be built to make briquettes from a combination of charcoal dust and raw organic materials.



The plastic hand press uses drainage pipe, a base board, a simple timber compressor (piston) and a central pole (also made of plastic pipework). This press will produce a large, doughnut shaped briquette that burns evenly and is well suited for use in rocket stoves.

A simple steel piston press can be made to mould & easily release the compressed briquette mix.



For larger scale briquette production, the steel-cylinder style press can be incorporated into a multi-briquette press that will produce up to 24 briquettes in each pressing.

f) Making a Steel Piston Press:

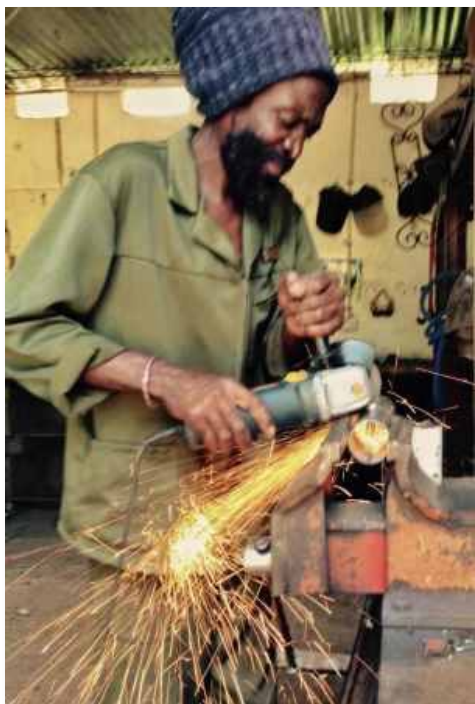
This is our **favourite** (and cheapest) press / mould kit. It is best used with the Fuel Briquette recipes that are made with a porridge binder. It produces high quality briquettes quickly and consistently.

The single piston steel press can be made simply from waste steel pipework, metal rods and a timber block for \$2 - \$3.

Waste steel pipe of 50mm - 100mm diameter is cut to a length of 150mm - 200mm.



A metal base plate is drilled to allow a strong metal rod to be inserted easily through the hole.



The metal plate with the hole is welded to the bottom of the steel cylinder. It is then cut around the cylinder, forming a base. It must be cleaned off to have smooth & safe edges.

Circular plates are welded to one end of 2 metal rods.

The circular plates must fit easily inside the steel cylinder.

One of the metal rods should be at least as long as the cylinder and must fit through the hole in the cylinder.

The other rod should be approximately 50% longer to allow it to be held when it is used.





Once the welding of the cylinder base and the rods has been completed, all edges and surfaces must be sanded and smoothed because the equipment will be used by hand.

The top end of the cylinder is left open. The base plate of the cylinder has a central hole in it.

The **shorter** rod (piston) fits **into** the cylinder with the rod through the hole in the circular plate at the bottom of the cylinder.

The **longer** rod (Piston) will be used for compressing the briquette mix.



Finally, a wooden block is required. (The block does not need to be as large as shown in these pictures.)

The timber block must have a hole in the top that is wide enough and deep enough to allow the **short** metal piston to be dropped into it once it is inside the steel cylinder.

The **longer** piston will be inserted into the open end of the cylinder once it has been filled with briquette mix.



g) Using a Steel Piston Press:

This type of briquette press is strong, light and cheap to make. It allows briquettes to be made quickly and to a constantly high quality. Our experience is that 2-3 people crushing charcoal, making porridge, mixing the basins and moulding briquettes with 2 of these presses can make between 600 - 1,000 briquettes per day.

Typically 5 - 8 briquettes will cook a meal for an African family - including beans, which take hours!

1) Place the shorter rod (piston) into the cylinder, through the hole in the base.



2) Load the press with charcoal mix so that it is about 2/3 full. This can be done by hand or by using the cylinder as a scoop.

Place the cylinder onto the wooden block with the piston shaft in the hole in the top of the block.



3) Place the long piston in the top of the cylinder and hit the rod 2 - 3 times with a hammer, a piece of wood or a stone.



4) Lift the cylinder out of the hole in the wood block and rest the end of the bottom piston on the top of the wood block.



5) Push the cylinder down onto the top of the wood block. The cylinder will stay in place and push a briquette out the top.

3 - Charcoal Making - Fuel From the Fields;

Fuel Briquettes are most efficient when made with charcoal waste (fines) that are too small to be sold. If these are difficult to find or become expensive to buy, charcoal can be 'home-made'.

Suitable materials include Maize cobs, banana leaves, sugar cane waste (bagasse), waste coffee husks, waste timber, sawdust, etc.

The process can be applied to a variety of agricultural or garden waste. It requires little equipment and a bit of practice in order to ensure that the raw materials are properly pyrolyzed (super-dried into charcoal) but it means that rural communities truly can create **Fuel From the Fields**.

Create a kiln from an oil drum.
Make sure it is clean of any fuel residue.

Cut a hole in the top and make a plate / lid to be able to cover the top hole during the charcoal making process.

Also cut 6-7 holes in the base to be able to light a fire underneath the drum.



The removable lid for the drum should have a small metal hoop welded onto it so that it can be lowered over the drum from a distance once the fire has been lit.

The drum does not need to be new, but should have no holes in the sides.

Holes in the drum sides would let air into the drum once the burning has been stopped.

That air would prevent the materials (maize cobs, sugar cane waste, etc) from being properly 'carbonised'. Turning waste into charcoal relies upon heat **without** flame and drying **without** oxygen.

1) Stand the drum on 3 bricks. Arrange kindling and timber beneath the drum to light a fire.

2) Place a thick pole in the centre of the drum, down to the bottom. This will be removed later and create a hole that will act like a chimney.

3) Load the drum with alternating layers of maize cobs and dried leaves.

The maize cobs (or whatever waste is being used) must be **very** dry.

Place approximately 100mm of dry leaves in the base of the drum, then a 300mm layer of maize cobs, another layer of leaves, then another 300mm of maize cobs. Continue until the drum is full

4) Once the drum is full of layers, remove the cobs down to just below the hole in the top of the drum.

Then, carefully remove the pole. This will leave a hole from top to bottom inside the drum, through the maize cob layers.

5) Light a small fire under the oil drum. Once this has caught, it will create great heat at the base of the drum and will set fire to the material inside the base.





6) The fire may be a little difficult to keep alight at first, so extra wood at the base may be required.

Stick with it - the important thing is that this fire will create a small but very hot fire at the base of the drum as the bottom layer of leaves burns.

7) As the fire under the drum burns, smoke will come from the opening in the top of the drum.

Although it looks like the material in the drum may be burning, it is not. This is just smoke rising through the hole that was left after the pole was removed.



As time goes on, the smoke will appear to get much thicker.

In fact, this is not just smoke. It is mostly thick steam, mixed with a small amount of smoke.

The smoke will become 'yellow' coloured and, if you put your hand into it above the drum, you will feel how damp it is (be careful, it is still hot!).

Even if the maize cobs appeared very dry when they were loaded, there will still have been a huge amount of moisture in them.

Now the process of making charcoal is **really** beginning .





8) After 45-60 minutes, the steam / smoke mix coming from the top of the drum will have dried a lot.

At this point, most of what is coming from the top of the drum are fumes from the drying process. These fumes can be toxic, and should not be breathed.

9) The fumes can be difficult to light. Use a torch for safety. If the fumes do not light first time, it is because there is still too much moisture in the smoke / steam mix.

TAKE GREAT CARE, when dry enough the fumes will burn easily. Burning them off is the safest way to deal with them, but lighting them can be tricky.



10) Although it looks like the contents of the drum are burning, THEY ARE NOT.

This is the pyrolyzation process taking place. The small fire at the base of the drum is sucking air into the drum. This air is accelerated as the heat rises through the chimney inside the drum. The small gap caused by the bricks under the drum small accelerate the airflow even more.

Lighting the fumes at the top of the drum creates very hot air, which rises, and sucks air into the bottom of the drum at even higher speed.

There is very little fire in the drum itself.

After the fumes have burnt for between 15-30 minutes, the oil drum will need to be covered so that the charcoal-making process can really begin.

11) At this point, to actually make charcoal the fire **must** be put out. If it continues to burn, the contents of the drum will burn to ash.

To make charcoal we **must** cut off the supply of oxygen to the fire and allow the material to super-dry.



12) The drum must then be taken off the bricks so that the gap at the bottom is closed.

This can be dangerous. Everything is **VERY HOT**.

The best way is to have 3-4 people with long poles who push the drum slightly backwards from one side. The brick on one side can then be kicked / knocked away.

The process is then repeated with the second brick. And then again with the 3rd brick. As this is done the drum is very unstable and the process **MUST** be done carefully and quickly.



We do this by sealing the top and the bottom of the drum so that no air can get into it.

The steel lid must be carefully lowered over the opening in the top of the drum.

This is best done by putting a long pole through the steel hoop welded onto the top of the plate and lowering the plate onto the drum from a distance.



13) Finally, to completely seal the drum, Earth must be packed around the top and the bottom.

This cuts off the air supply through the holes in the base of the drum and the gaps around the lid at the top.

14) The drum must be left for at least 24 hours for the pyrolyzation proceed to continue and the contents to cool.

The drum will remain **VERY HOT**.

After 24-36 hours, the earth can be removed from around the drum and from on top of the lid.

The lid is then removed and the charcoal can be inspected.

As can be seen from this picture, there has been very little fire inside the drum itself and, in this example, not all of the maize cobs have even been pyrolyzed.

This is why it is important to experiment with different burning times for:

- the fire under the drum,
- the time before lighting the fumes at the top and
- the time to allow these fumes to burn before putting the lid on and dropping the drum off the bricks.



15) Once the drum has cooled, its contents can be emptied and the pyrolyzed maize cobs (now turned to real charcoal) separated from any cobs that have not completed the carbonising process.

None of the un-pyrolyzed material will be wasted. The partly processed cobs can be collected together in sacks and then re-processed next time.



4 - Making Simple Rocket Stoves;

What are Rocket Stoves?

Rocket stoves are simple, but improved cook stoves that rely upon 2 main principles:

- 1 - the drawing of air through a small aperture in order to create an accelerated airstream
- 2 - containing the heat of the fire within a stove

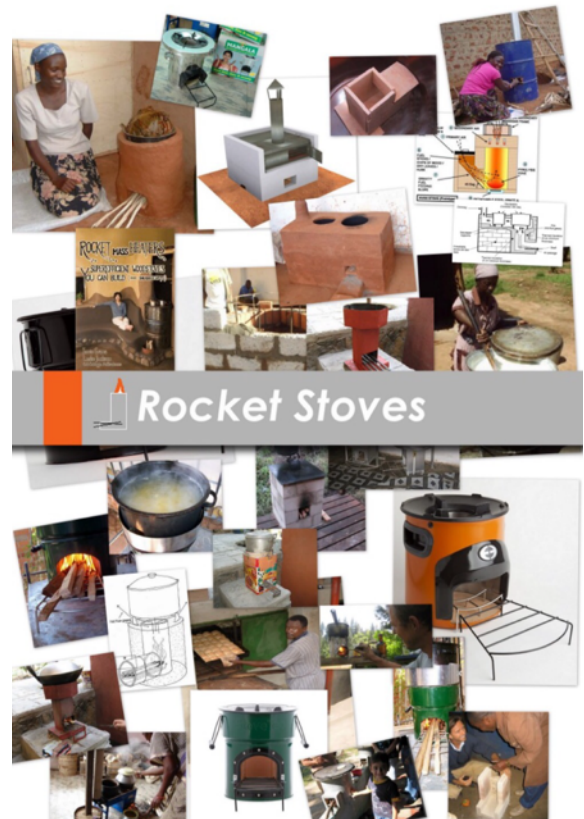
There are many types and styles of stoves available to be bought or made simply and cheaply.

They can be made as lightweight portable stoves or as fixed, multi-burner stoves that use a single source of timber, charcoal or briquettes.

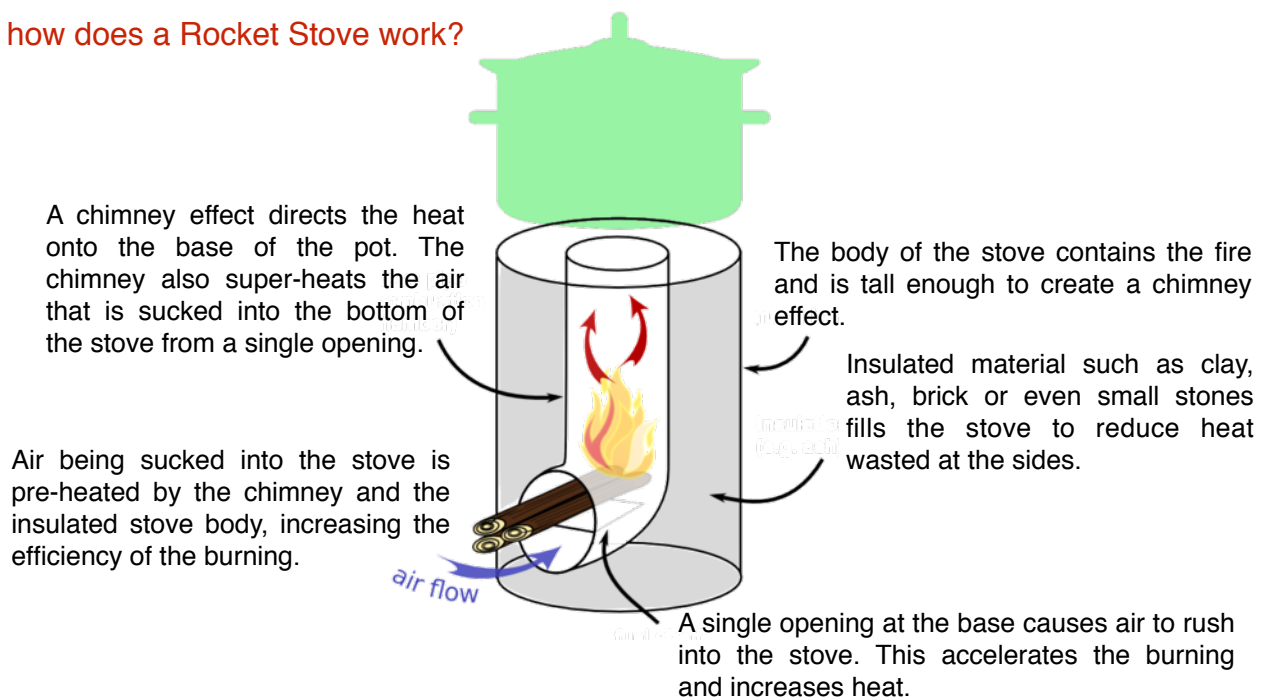
Generally, a 3-stone fire or a brazier-style fire is approximately 12-20% efficient when used with firewood.



This efficiency is doubled when a Rocket Stove is used. When a rocket stove is used with Fuel Briquettes the efficiency is increased to 4x what is achieved using normal cooking methods. Cooking is quicker, cheaper and cleaner.



So, how does a Rocket Stove work?



Rocket Stoves can be made from many different materials, depending upon what can be found locally and what tools / skills are available.

They can be made from lightweight breeze-block...

Or regular mud bricks, mortared together...



They can be made from tin cans of various sizes, separated from each other by a layer of insulation such as, mud, stones, etc...



Or made from clay or cement moulded around pipework...



In all cases, it is possible for women to make these stoves within their own communities and, by using them, make significant savings on fuel costs.



Perhaps the simplest way to make a Rocket Stove is to use clay and a simple former such as a pole from a banana plant.

1) Collect a pile of clay / mud and, over a period of 2 days, beat it with the back of a hoe to ensure it is well mixed and any stones have been removed. The mud should have as high a clay-content as possible.

2) Break up the fibres of some dried banana leaves or strong grasses, also using the back of a hoe or a stone. The fibres will add strength to the clay when it has dried.



3) Mix the fibres into the pile of clay. Beat the clay / fibre mix again with a hoe to make sure all the fibres are mixed in thoroughly.



4) Collect a banana pole (or plastic drainage pipe, etc) to act as a mould for the clay.

5) Cut the pole in half (these ladies know how to use a knife!)



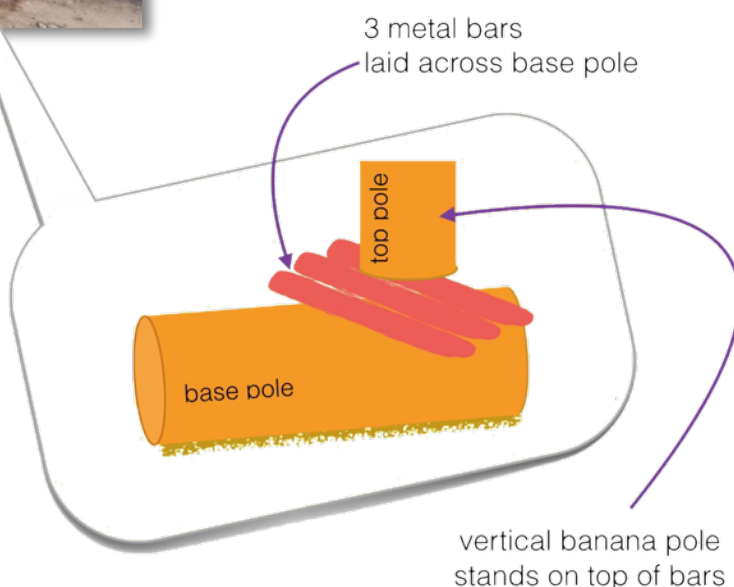


6) Lay one half of the pole onto a piece of sacking or a strong sheet so that the clay does not stick to the ground. The pole should be wrapped in a banana leaf (or plastic bag) so that the pole can easily be removed once the moulding has been completed.

Then, as often happens when a group of women get together, **Let The Mud-Slinging Begin...**

The mud is thrown at the pole to make sure that it is well compressed. The far end of the pole should also be well covered in the mud so that the hole that the pole creates **does not** go right through the base of the stove. In this way, a hole will be created only at the front of the fire.

7) **Before** the mud builds up too high on the top of the pole, 3 or 4 short lengths of metal rod (approx 150mm - 200mm long) must be placed across the top of the banana pole approximately 20-30mm apart. When the stove is complete, these will form a grate in the bottom of the fire through which the ash will fall.



8) Stand the 2nd half of the banana pole on top of the metal bars. This pole should also be wrapped in a banana leaf so that the pole can be easily removed later on.

Continue the mud-slinging!

Make sure that there is plenty of mud around **all** surfaces of the pole on the sack **and** the pole standing upright





9) Once a large pile of well-compressed clay / mud has been created, start to shape the mud pile into a cube with a large knife.



10) Remove the top pole, and then the leaf that was wrapped around it. The metal bars will remain in place at the bottom of the hole and the clay can be cleaned away from them later. Shape the top of the pile of mud with a knife to make it flat.

Take care at this point - it is important not to loosen the mud or break it up too much.



11) Smooth all internal and external surfaces of the stove with wet hands and the flat side of a wet knife blade.

12) Make 3 'sausages' of clay and carefully fix them onto the top of the fire. These will become the stand for any pot used on the fire.



13) Continue to smooth the internal and external surfaces of the fire to make a good finish.

It's thirsty work.



14) Put a pot on the top to test the size and that the pot-rests are level & safe.

Stand back - Admire your work!



15) Finally, make a paste out of water and the starchy leaves of potato plants or cassava plants.

Rub this carefully all over the external surface of the stove while the clay is still slightly wet (sometimes this is easiest 18-24 hours after the smoothing has been finished and the clay is a little drier).

This paste will seal the outside of the stove and make it last longer by helping to stop the clay from breaking up or crumbling once it is dry.

It may take 5-7 days for the clay stove to dry. Try to keep it out of the rain during that time (possibly cover it with another sack for a while) and try not to move it around. Finally, once the stove is completely dry, remove the bottom banana pole and the leaf that was wrapped around it. Carefully clean away any remaining clay from around the metal rods that were placed in between the bottom and the top banana poles.



Your Rocket Stove is now ready to be used.

Before using the stove for cooking, 2 or 3 small fires should be lit in it to gradually cure and fully dry the clay.

The information in this manual has been collected over a 2-year period of training & development by AmahaWe Uganda team members with street-kids and women's community groups in Uganda & Zambia.

Technical data and testing literature for briquette making & burning is available from the email address below.

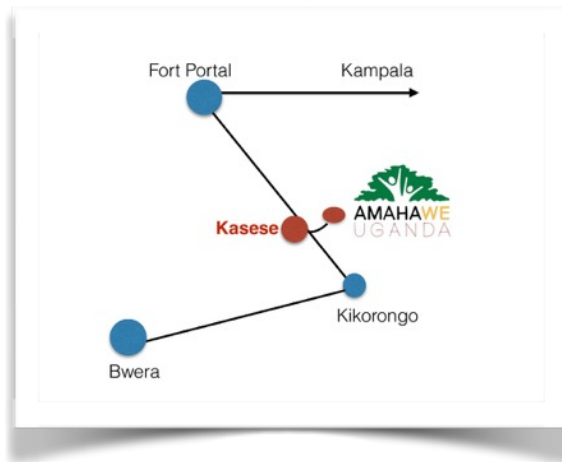
Laboratory testing data were provided by **MIT d-Labs** in Boston and **Oxford University**.

More information regarding the activities and people involved with AWU, is available at:

The AmahaWe Uganda website:
www.amahaweuganda.org

or by email from:
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or from our blog at:
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