# Malawi Report

Feb 1st – April 11th, 2005

- 200L Institutional Brick Rocket Stove
- Stove plans for the 110L and 200L Brick and 200L Double walled metal stove
- Rocket Water Geyser/Heater
- Excel design for Metal Household and Institutional stoves
- Household Rocket Prototype
- New Rocket Stove Producers in Malawi

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# 1.0 Material Outputs

## 1.1 New 200L Institutional Brick Stove:

This stove is built with an Internal pot stabilizer. This metal 'skeleton' creates the ideal gap between the pot and the stove body.

A **legless** metal shelf is now used to support the wood in the combustion chamber.

The top of the stove slopes away from the cooking pot, allowing water and food to drain away to the floor and not seep back into the stove body. The stove is given a metal 'float' finish to allow for easier cleaning.

A removable wooden mould is used to construct the combustion chamber. The mould is designed to create a ledge that will support the legless metal wood shelf.

Material cost for stove:  ~ US$100
Material cost for pot:: ~ US$200-300

Please see:200L Brick Stove Plans for more details.

## 1.2. 210L Rocket Stove Batch Water Heater/Geyser

- Built at EP Eldorado Tea Estate
- Retail price: ~ US$400
- Preliminary tests carried out by Central Workshop/EP Tea Estates showed that the Rocket Stove Geyser took about the same amount of time to heat water as the Kenyan Geyser: 1.5hours to heat water from 36°C to 72°C as compared to the Kenyan Geyser: 1.75 hours to heat water from 30° to 70°C.
- Even though the amount of time taken was similar, the Rocket Stove Geyser consumed **75% less firewood** then the Kenyan Geyser. See Appendix A for Schematic.

## 1.3. Ken Steel Engineering Brick Geyser

Ken Steel Engineering built this brick Rocket Stove geyser in January 2005. I support the use of brick to build the geyser body, as it will be considerably cheaper than the metal version (even though it could marginally reduce the efficiency of the geyser). Future geysers should be built with the *geometry* that was used in the metal geyser at Eldorado Tea Estates (i.e. figure 1.2) regardless of whether it is made from brick or metal. We should **not** build more Geysers using the geometry of Ken's Geyser.

## 1.4 Household Rocket Stove Prototype

Working closely with Andi Michel, we developed a number of new Rocket Stove prototypes. Dedza insulative bricks were used to line three of these stoves. In an attempt to lower production costs a number of insulative bricks (both kiln-fired and 'raw') were produced in Mulanje.

The stove shown on the left was considered the House hold Rocket Deluxe as it featured a thicker (.8 mm) mild steel stove body and Dedza insulative bricks. Work is still being done to make a cheaper version of this stove for lower income groups but there is still a considerable market for this deluxe version.

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## 1.5 New Dover Stove Mk2

This stove was designed to replace the traditional (and expensive) cast iron Dover stove that was typically installed in a manager's house at the tea estates. The builders at CWS have since built at least 2 more of these new Dover stoves. A number of improvements have been made to this cook/bake stove since the initial prototype was introduced in 2004, such as:

- A chimney outlet at the side of the stove as opposed to through the top plate The larger top plate/cooking surface is now able to accommodate 4 medium size pots.
- A folded 4.5 mm top plate instead of the bolted plate.

# 2.0 Stove Plans and Design Guides

**2 sets of Stove Plans**:
- 110L Half Drum Brick Stove Plans
- 200L Brick Stove Plans

**2 Excel design guides**:
- Household metal Rocket stove design guide
- Institutional metal Rocket Stove design guide

**2 stove design guides (Microsoft word):**
- Brick Institutional Stove Design Guide
- Metal Institutional Stove Design Guide

**1 design guide for Pot development:** (note: this is made for producing pots from stainless steel sheets i250 by 2500 mm)
- 100L and 200L Pot development design Guide

# 3.0 Stove Producer Trainings

In Feb 2005, a Rocket stove training was given at IFSP Mulanje for prospective stove producers and technicians in Malawi. A total of 15 metal workers and bricklayers came from Llongwe, Mzuzu, and from Lujeri, Makandi and Eastern Produce Tea Estates. The workshop lasted 5 days and was designed to teach the students how to build brick and metal institutional stoves.

On the first day we visited the 100L brick and 200L double walled metal institutional Rocket stove at Lauderdale Tea Estates and introduced the trainees to the principles of the Rocket Stove.

On the following 4 days, the bricklayers and metal workers divided into two groups. The Bricklayers built a stove to fit a used 110 L drum. 110L Half Drum Brick Stove Plans

Using the principles that they had used to build the 110L stove, they then designed there own 2-pot brick restaurant stove.

The metal workers built a 110 L WFP stove at Ken's Steel and Engineering, as well as the metal skeleton for the inside of the brick institutional stove.

Following the training, we decided to support two of our best trainees - Harold Mkandawire and Edson Kunthani in Mzuzu and Patrick in Llongwe – to develop a commercially viable Rocket Stove business. As of April 2005 Patrick had built one 25 L Rocket Stove.

Directly following the training, Eastern Produce (Glenorchy Estate) built 2 of the new 200L brick stove design; Lujery built a brick and a metal institutional stove; and Makandi was finalizing plans to install nineteen 200 L stoves

## 3.1 Training

### Way Forward

At the moment most of the Institutional Rocket stoves that are built in Malawi are made from metal. Due to the durability and transportation challenges that we have faced with the metal stoves, I would recommend that we try to promote the **brick institutional stove** in favour of the metal stove. To do this we have to increase the capacity of artisans throughout Malawi to build these stoves.

Another training should be conducted for bricklayers to build institutional stoves. A number of the bricklayers that were selected for the training in Feb 2005 were, unfortunately, not natural entrepreneurs and/or did not have the desire or time to start a new stove business.

The next training should focus on expanding Ken Steel Engineering's capacity to create a full time, mobile team of brick stove builders as well as to expand the capacity of other brick builders in Central and Northern Malawi. A request for trainees should be posted in the newspapers and circulated by other means as possible. Applications should be made by prospective trainees and reviewed by ProBEC. The selection process is essential to the success of the training.

# 4.0 Ken Steel Engineering


The institutional Rocket Stove was introduced to Mulanje in March 2004. Our initial goal was to develop a series of Rocket stove prototypes and then support a small local businessman to develop a commercially viable business to produce and sell these stoves. Ken Chilewe, our first trainee, ran a small metal fabrication company that specialized in metal doors and gates. He had no previous experience in the stove business. Now Ken employs 18 people, including a sharply dressed sales team (see photo right) that travels through out Malawi selling stoves. Kens team has built and sold more than 300 Institutional and Restaurant Stoves.

Since March of 2004, Ken Steel Engineering has built a number of different Rocket stoves, each one modified to fit a specific pot and cooking situation.

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They have built:

- 2 pot restaurant and school stoves,
- retrofitted 250L oil electric stoves,
- brick and metal institutional stoves
- water heaters/geysers

His two biggest selling stoves have been the 2-pot restaurant stove (shown left) that retails for approx US$ 260 and the World Food Program stove (shown below) that retails for approx US$200. At Emanuel Teacher training college, where this stove was installed, fuel wood consumption has been reduced from US$ 700/year to US$350/year.

The stoves are coated with High temp Aluminum paint (supposedly rated to 600C) that turns a gold colour when exposed to the heat of the combustion chamber. The skirt maintains the aluminum finish.

These stoves are lined with Dedza HTM-5 mortar. After three months of daily use, the High Temperature Mortar that lines the combustion chamber is still in tact.

Ken has sold more than 120 metal 110L stoves to WFP, which has then disseminated the stoves to the schools that they support through their School Feeding Program. Although initial feedback for the stoves is positive, both WFP and ProBEC agreed that it would be better, wherever possible, to build a non-portable brick stove.

# 5.0 Pot Development

This is a pot made by Ken Steel Engineering. They feature a 3mm stainless steel bottom and 1.5 mm mild steel side and top. Although we would recommend using 1.5 mm and 3 mm stainless steel for all of the pot to ensure that it is durable, hygienic and long lasting (10 years+), this pot seems to fulfill the needs of schools and other institutions that cant afford a stainless steel pot. We will monitor these pots closely to see how they perform in the long term.

**Please see the** 100L and 200L Pot development design Guide for ideas on pot development

# 6.0 Quality Control

ProBEC North, in conjunction with the Ministry of Energy, has developed a Quality Control Program for the Rocket Stove. While eventually the Bureau of Standards (or some other government organization) will be responsible for quality control, it was recognized that a stopgap measure was needed to ensure quality control in the short term.

In other countries, such as Kenya, the Ministry of Energy and other partners are trying to initiate a quality control program for the Kenyan Ceramic Jiko, 20 years after its introduction. The problem with initiating quality control systems long after introducing the stove is that now there are thousands of mediocre producers of the KCJ and the price has fallen to the point that few people are willing to pay for – and few producers know how to make - a 'real' Kenyan Ceramic Jiko. In Malawi our goal is too support the production of quality right from the onset so that certified producers can get a foothold in the market.

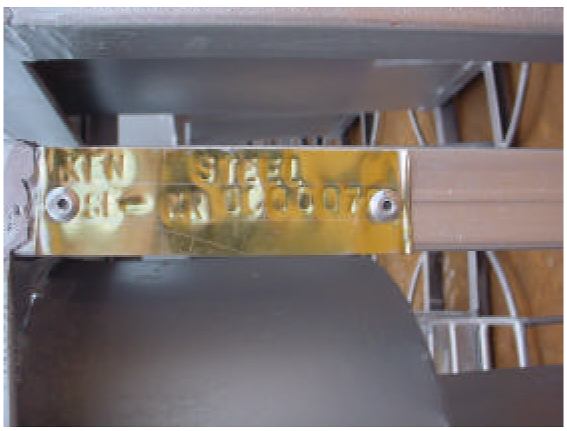
While it is true that we can't stop imitators - who will try to make an inferior and cheaper product - we can educate the public on the benefits of buying a certified Rocket stove.

Quality control is maintained through a number of channels.

1. The Stove, not the producer, is certified.


A comprehensive checklist (see Quality control guide) is used to ensure that the each stove has been built to ProBEC's standards. Once this has been ascertained, the certificate is signed and dated and given to the purchaser. The producers name and number are also printed on the certificate

2. The development of a recognizable logo that people will associate with a quality product.  .


3. A numbered serial plate is attached to each stove. This allows ProBEC to track the stove in the future (who made the stove and when) and establishes the authenticity of the product for the purchaser.

4. Each stove is delivered with a user guide. It is important that all of the end users are trained in the correct use of the stove. (The cost of this training needs to be factored into the stove price). However, due to the nature of institutional kitchens, which have a high staff turn over, it is important to have a printed user guide (see Institutional User Guide) that can be used to teach new staff as well as to refresh the minds of the original users. This guide should be laminated and posted in each kitchen.

**DO** use the proper size pot. The pot should fit snugly inside the stove and create a 1-1.5 cm gap between the pot and the skirt. **Regardless of whether you are cooking 10 litres or 100, the same pot should always be used**!

# 7.0 Insulative Bricks

At present all of the insulative bricks that are used in institutional stoves in Malawi are made at Dedza Pottery. When transported with care and used correctly these sawdust/grog/clay bricks provide an excellent insulative refractory brick. Our goal is to build a combustion chamber for both the institutional and household stove that is light, refractory, insulative, and durable. Our focus for the household stove is **affordability** whereas our focus for the institutional stove is **durability**. To this end, we have enlisted the research team at Dedza pottery to help us.

Over the next year Dedza has agreed to develop a lining or abrasive resistant face for the Institutional Stoves; some ideas that would be tested would include:

- Applying a glaze or glaze-like material to one face of a brick.
- Applying a "plaster" with and without cement to the faces of a brick
- Developing a thin lining of tiles or other material to protect the insulation bricks.

Dedza will also develop processes to make low cost yet high quality insulation bricks for the domestic stoves. This would include looking at:

- Idea of using unfired bricks in the stoves that would be fired 'in situ'
- Making bricks using the type of clays that are commonly found throughout Malawi.
- Developing brick making processes that require low capital cost equipment.
- Develop brick making processes that can be mastered within 1 – 3 months by persons with determination but perhaps only primary school education.

## 7.1 Way Forward/ Recommendations

We have two potential streams of research to improve the durability of the insulative combustion chamber for the institutional stove. The first is to develop a thin coating that can be fired on to an insulative brick as per our research with Dedza. One option is to explore recipes that have been used other countries. In Uganda, for example, a hard coating is made with:

- Feldspar 25%
  Sand 23%
  Kaolin 40%
  Ball clay 10%
  Whiting 2%

This is wet milled, applied to a brick, and then fired at 1250C. A similar recipe should be attempted in Malawi as well.

The 2nd stream of research is for the development of an abrasion resistant, thin (5-10 mm thick) non-insulative refractory pipe that is then surrounded by a low-density insulative material when the stove is being assembled. This hard liner will withstand the abrasion of the sticks and, because we can use an even lighter (non-kiln fired) insulative mixture around the pipe, there will be no reduction of efficiency. Transportation would also easier as the pipes would be less fragile and take up less space as compared to the insulative brick

We can also experiment with circular insulative bricks (disks) to build the combustion chambers. Circular bricks are easier to assemble: they use less mortar and are free standing. We should make 10 sets of circular bricks to fit inside 10 institutional stove circular combustion chambers.

# 8.0 Mortar

Generally speaking, the basic components of a refractory mortar are, by volume:

- 1-3 parts finely sifted grog or stable aggregate (such as fired clay or mullite
- 1 part binder (e.g. high temp cement or refractory plastic clay).

Note:a mortar for binding bricks should **not** be insulative, so no sawdust or other lightweight material should be added.

If other materials such as sodium silicate are available, than these can be added for their extra strength and air setting capablities. In South Africa we learned of this recipe for refractory mortar. By weight:

- 66% grog powder
- 12% fine plastic clay  (can be non-refractory or refractory)
- 21.5% sodium silicate liquid

In the case of Malawi, where sodium silicate is difficult to procure, we have been using Dedza High Temp Mortar (**HTM-5)** since 2004.**This is made from 1 part Grog and 1 part High Temp clay.**

The **grog** is made by mixing two parts sawdust (sifted through a #10 mesh) with one part high temp clay and then fired at 950C for approx 12 hours. It is 'soaked' for 2 hours at 950C. It is then cooled and sifted through a #60 mesh. After the grog is fired and sifted, it is then mixed with 1 part high temp clay (sifted through a #60 mesh). Note: grog can also be made by simply crushing and sifting clay that has already been fired. Ideally this clay should have been fired to 1100C so that it is calcined and stable

The grog and clay are then made into a runny paste and thinly applied between the bricks (3-5 mm joints). **HTM-5 mortar** is heat setting so it will only become hard once it is fired in the stove. As this is problematic for stoves that need to be transported before they are fired, we have recently switched to **HTM –6:**

- This is made by mixing 5 parts HTM –5 with 1 part Portland cement

The addition of the cement will allow the mortar to partially air set. This mixture is used to decrease drying times and increase stability during transportation. Under normal circumstances, we prefer not to recommend the use of cement in refractory mixtures.

In the case where an insulative refractory mixture is needed (such as to insulate the top plate of the institutional stove) we are now using a mix of **1 part HTM-6 to 1 part dry sawdust** (sifted through a 2mm mesh).

After applying any of these mixtures it is important for them to dry slowly in the shade. If cracks develop, then the mortar should be re-moistened and then filled with a small amount of mortar to fill in the cracks.

At present we are using the HTM-6 (and previously, the HTM-5) to make a liner/plaster on the inside of the combustion chamber to help protect the insulative bricks from the abrasion caused by roughly pushing firewood into the stove.

This liner/plaster has been effective when the stove is used carefully (for example, the stove that was installed at Emanuel Teacher's college in Blantyre). This approach has been less successful in environments when the stove has been used more roughly, such as at Maula prison. Although, in the case of Maula prison, the stoves that were damaged may have been left out in the rain for two weeks so this might have degraded the bricks even before the cooks damaged the stoves.

Even so, we want to use the strongest liner/plaster possible. Mortar specialists at Veerenging Refractories in South Africa suggested that we make a liner that uses a larger particle size of Grog than the Dedza HTM- 5 or HTM-6 mixture. Rule of thumb: the thicker the liner, the larger the particle size of the grog. They suggested this mixture for a 10 mm thick liner

- 35 % 4 mm to 2 mm grog

- 35% 2mm to 1 mm grog
- 35 % plastic clay (If sodium silicate is available then it could be substituted (~50%) for the plastic clay

While we are waiting for Dedza pottery to perfect an abrasion resistant fired combustion chamber, we should experiment with this mixture to line the inside of the institutional stove.

# 9.0 Household Rocket Stove (HHRS)

At least 6 Household Rocket Stoves were made in the spring of 2005. Three of these were made with Dedza bricks and the others were made with a mixture of fired and raw insulative bricks. For more info on these bricks please see Andi Michel's brief report on homemade bricks.

The price of the Dedza insulative bricks for the household stove is between US$8-10. The final retail price of this 'deluxe' stove will probably be approx US$30 so we still need to explore a cheaper option. This price, however, might still be acceptable for some middle income families and chip sellers

# 10.0 Chip sellers

In March of 2005, we interviewed a number of chip sellers in Mulanje and Blantyre. In Mulanje, the chip sellers spent, on average, 100Kwacha (aboutUS$.90) on wood and sold about 1000K worth of chips each day. In Blantyre, on the other hand, chip sellers spent approx 300K on firewood and sold 2700-3500K worth of chips per day.

This means that **each chip seller in Blantyre spends almost US$1000 /year on firewood**. The chip sellers that we spoke to in Blantyre were desperate for a new stove and were willing to pay for it. At present they spend 500K to purchase a very inefficient mbaula or use an old car tire rim.

Due to the high cost of the chip frying pan (US$15+) we decided to design a stove that could attach simply to the bottom of any frying pan. Andi Michel built a prototype but my understanding is that more work is needed on this design.

## 11.0 Maula Prison/Malawi Prison Service

One of the most promising clients for purchasing an institutional Rocket stove is the Malawi Prison Service. Maula Prison, near Llongwe, has some of the most wasteful kitchen practices I have ever seen. Obviously there have been few internal incentives to reduce firewood consumption. For example, the prisons in Malawi purchase the wood from the government but, according to prison officials themselves, the bill itself is rarely paid because it is a government-to-government purchase.

The cooks themselves are unskilled prisoners who are not trained and/or unconcerned with reducing fuel consumption. And, of course, until now, they haven't had a more fuel-efficient option.

While it is true that a number of oil electric stoves *were* installed in the early 90's, they were destroyed by prisoners. In other prisons across Malawi we have seen many oil electric stoves that have broken (during normal use) and remained unused for many years, as they are expensive to repair.

In the case of Maula prison, the stainless steel pots from these stoves were rebuilt into this inefficient and high mass stove (photo right).

These 250L pots should be salvaged from the high mass stoves and rebuilt into a Rocket stove.

According to prison officials, before the introduction of the Rocket Stove, the kitchen at Maula prison (which feeds 1900 people each day) required a **10-ton truck to collect 15 cubic meters of wood 8 times a week**. A dry cubic meter of wood weighs approx 356 kg.

This means that the Prison was using **42 tons of wood every 2 weeks** or 3 tons per day. One of the bills that Maula Prison does have to pay on a regular basis is for the fuel to transport the wood. The truck uses 65Litres (or approx US$60) per trip. This saving on transport costs could easily be rolled back into the purchase of improved stoves.

Since December 2004, five Metal Rocket Stoves have been in use (one retrofitted oil electric stove and four conical pot Rocket stoves) in the Maula prison kitchen. This has led to a greatly improved kitchen: no open fires, nearly smokeless cooking environment, and an incredible reduction in fuel consumption. **Maula prison has reduced its fuel consumption from 8 truckloads every two weeks to less than 1!** This also saves 900 Litres of diesel fuel each month.

# 11.1 Maula Prison

<u>The Way Forward</u>

The Prison should be encouraged to use a single standardized pot. Having different size pots means that sometimes a large pot is placed in a small stove (or vice versa) which lowers efficiency and can damage the stove.

A lip should be built on the pot to ensure that spilled food is diverted away from the stove.

The Prisons should switch to a standardized 250 or 300L stainless steel pot and a brick Rocket stove.

New mechanisms should be promoted on the governmental level to allow the prisons to order *and* pay for stoves throughout the country. At the moment many Prisons want stoves and have ordered them, but are unable to pay for them.

Well-trained cooks should replace the untrained prisoners to prepare the meals.

# 12.0 Tobacco Curing

Tobacco curing is a serious threat to Malawi's native forests. According to a report published by the Campaign for Tobacco Free Kids, entitled *Golden Leaf, Barren Harvest,* "In Southern Africa alone, an estimated 140,000 hectares of Woodlands [55,000 hectares in Malawi alone] are cleared annually to cure tobacco, accounting for 12 percent of the deforestation in the region, according to extensive aerial and satellite data as well as surveys of 565 tobacco growers in Malawi and Tanzania, both smallholders as well as those on the larger estates. In one region of the Namweran highlands in Malawi, **nearly 80 percent of all the wood cut down is used for tobacco**, even though tobacco farmers make up a mere 3 percent of the farmers in the area."

The following table shows the environmental cost of Malawi's tobacco production as compared to 5 other tobacco producing countries. Note: this data is now 6 years old, and given the rapid increase in Malawian tobacco production (due to the decrease in Zimbabwean production, following their political crisis) we could assume that all of the figures for Malawi are now considerably higher.

| **Country** | **Mean Annual Tobacco Production** ('000 tons) | **Total Annual Wood Consumption** ('000 tons) | **Area of Natural Woody Biomass Removed** hectares | **Total Annual Deforestation** ('000 hectares) | **Percentage of Tobacco Related) Deforestation** |
|---|---|---|---|---|---|
| South Korea | 85.5 | 272.2 | 5846 | 13.0 | 45.0 |
| Uruguay | 1.4 | 7.6 | 162 | 0.4 | 40.6 |
| Bangladesh | 55.0 | 128.0 | 2750 | 9.0 | 30.6 |
| **Malawi** | **125.4** | **485.4** | **14382** | **55.0** | **26.1** |
| Pakistan | 96.0 | 486.1 | 10443 | 55.0 | 19.0 |
| China | 3049.0 | 722.8 | 15527 | 87.0 | 17.8 |
| | SOURCE: Helmut Geist, "Global Assessment of Reforestation Related to Tobacco Farming," Tobacco Control, Spring 1999. | | | | |

Not only is tobacco production environmentally destructive, it is also expensive for the individual producers. Ralph Henderson, a tobacco farmer in

Southern Malawi, spends US$10,000/year for firewood to produce approx 500 tonnes of finished tobacco.

According to anecdotal reports, most tobacco growers do not grow their own wood. Growing you own fuel wood is cheaper, but tobacco producers, especially small scale farmers, have not had the financial means or access to land to grow their own wood. Whereas tea plantations such as Makandi Tea Estates might spend US$ 40,000 for fuelwood each year for drying tea, they provide this from their **own** Eucalyptus wood lots. Tobacco producers, on the other hand, buy whatever wood they can get on the open market - from other wood lot owners and, more often, from native forests.

Three types of curing barns are used in Malawi, but **most of the tobacco is cured in traditional barns** similar to the one shown in the photo on left. In the traditional barn there are 5 drying rooms that are fired with 5 separate wood combustion chambers. The 5 chimneys that correlate to the combustion chambers are visible in the photo.

The combustion chambers themselves are over sized, un-insulated and do not have the proper geometry for clean combustion of wood. The fire needs to be tended constantly. Sometimes the feed chamber is over-fed in the evening to allow for less tending in the night.

The heat transfer mechanism is very simplistic. Cold air is drawn through 4 small openings at the bottom of the barn (1 of these is shown in photo left).

This air is then heated by the exposed chimney pipe that snakes around the bottom of the barn. This hot dry air whisks moisture from the tobacco that is then vented through an adjustable gap in the ceiling of the barn.

Although some work was done in Zimbabwe to improve these barns in the 1970's, the curing method has remained relatively unchanged for more than a century. Each drying room is filled with 500-1000 kg of tobacco and a wood fire is used to dry it for approx 8 days. The tobacco curing process is very temperature and time dependant so solar drying does not appear to be a feasible option at the moment. However, many improvements to the existing wood fired system are possible. This fall, to improve the traditional barn, we will:

- Retrofit one of these barns with a self-feeding insulative rocket stove combustion chamber made with Dedza bricks.
- Improve heat transfer between the incoming cool air and the hot flue chimney pipe.
- Utilize the flue chimney to increase the convective flow of warm air through the tobacco.

Our goal is to work with local bricklayers and existing tobacco barn construction specialists (such as John Whiteman) to train them how to incorporate Rocket Stove principles into the tobacco curing process.

In addition to the traditional method, Ralph Henderson also operates 2 improved curing barns. The curing barn on the left uses an air-to-air heat exchanger to heat multiple barns with a single combustion chamber. This combustion chamber (approx dimensions - 4 m by 3m by 3m) is used to heat a large metal plate and series of metal tubes. A fan drives air from the outside, through these pipes, and over the plate and into 5 separate curing rooms.

The second barn (shown left) uses a single combustion chamber (about half the size of the previous barn) that heats a 4500L kettle to 70C. This hot water is then piped through a radiator. A fan blows across the radiator and sends the hot air through 5 curing rooms. These barns are considerably more efficient (and expensive) than the traditional barn.

These two modern barns have a sophisticated method for moving air from the heat source to the tobacco but they still suffer from very poor combustion and flue gas to air (or flue gas to water) heat transfer. This fall we will improve the combustion efficiency and heat transfer for both modern curing barns.

Is the traditional curing barn still relevant?

Due to the nature of tobacco drying it is still necessary to use **both** the traditional and the modern barns. The modern barns are the preferred option during the peak season when a sufficient volume of tobacco is available to fill all of the curing rooms. During the beginning or the end of the season when volume is down it is preferable to use the traditional barn. For low income or small-scale farmers, the cost of a modern barn (~US$60,000) is not even an option so they are forced to use the traditional method.

All three of these tobacco-curing systems have their own merit and each one can be improved through the application of Rocket Stove Principles.

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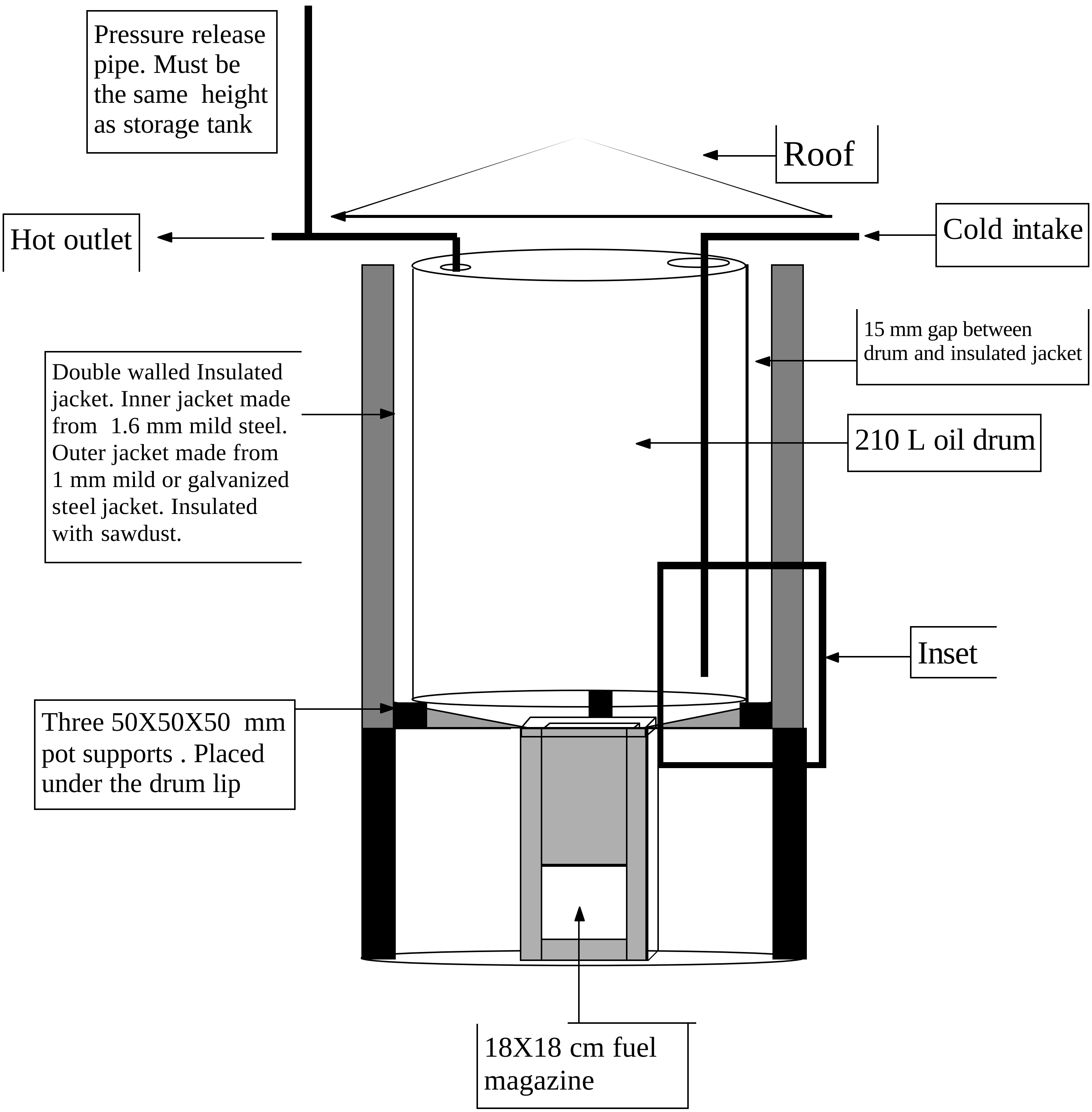
# Appendix A Water Heater/Geyser Schematic



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