Introduction of Rocket Stove Technologies (Institutional stoves, Household stoves and insulative refractory bricks) Into Malawi

March- July 2004

Draft Report

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Prepared for ProBEC South
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1.0 Material Outputs

(Please note: plans for all of the stoves in this report are available on limited basis. Please contact ProBEC for more information

Four portable 110L Stove Rocket stoves were built to accommodate the 110L WFP half drum pots

Two of these were made full size. One was delivered to WFP in Thyolo district. The other was left at Ken's Engineering in Mulanje as a demonstration model. This stove features:

- Light sawdust/clay/grog bricks (.67 g/cc) bricks and High Temp Mortar (HTM) made at Dedza Pottery.
- A removable shelf that is made from 4.5 mm mild steel (which will be replaced by Cast Iron in future models).
- A hinged 12 mm round bar wood support.
- 18cm by 18cm combustion chamber entrance

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two stoves were made with a slightly skirt and combustion chamber. This was reduce costs and conserve sheet metal enabling us to make two stoves from of 1.6 mm mild steel. The lower skirt will, extent, lower stove efficiency. No testing been done between the two stoves to the difference in efficiency

- 18cm by 18cm combustion chamber entrance
- Retail cost US$190

One 200L Double walled Portable stove

No smoke. No chimney!

- Salvaged Vermiculite Boiler bricks. Future stoves will utilize light sawdust/clay/grog bricks (.67 g/cc) and HTM mortar made by Dedza Pottery.
- A 1.6 mm stainless steel inner skirt and a 1.6mm outer skirt. Wood ash is placed between the 2 skirts
- A removable shelf that is made from 4.5 mm stainless steel (which will be replaced by Cast Iron in future models).
- A hinged 12 mm round bar wood support.
- 22cm by 22cm combustion chamber entrance

A CCT (Controlled Cooking Test) was performed by Andi Michael (ProBEC/ Oldenburg University) in July 2004. The stove cooked **Nsima for 220 people in 2.5 hours with 9.5 kg of dry wood**.

One 100L Brick stove

- Salvaged Vermiculite Boiler bricks. Future stoves will utilize light sawdust/clay/grog bricks (.67 g/cc) and HTM mortar made by Dedza Pottery.
- A removable shelf that is made from 4.5 mm stainless steel (which will be replaced by Cast Iron in future models).
- Pot skirt made from curved brick (which will be replaced by rectangular ‘soldiered ‘ bricks in the future)
- Fuel consumption estimated at 13 kg to cook 110 (200g) servings of nsima

The Brick stove design has been modified to incorporate an internal steel skeleton. See 100L way forward at the end of this report

Eastern Produce records show that that the 110L pot on the open fire uses **170 kg of wood per meal** (or approximately 160 kg more wood to cook half as much food).

A visual comparison between the quantities of wood used (170kg) for the open fire vs. the amount of wood used (13kg) by the 100L Rocket stove. Independently tested by EP Lauderdale Tea Estates (Malawi).

One 110 L Brick stove

This stove was built for Satemwa Tea Estates in Thyolo. This stove is slightly different than the 100L EP stove as it was designed to fit the common 110L half drum, not the custom built 100L stainless steel pot. Wherever possible, we should discourage the use of these drums and encourage the use of stainless steel pots.

- 20 cm by 20cm combustion chamber

One 100L Double walled Stove With stainless Steel pot

- Salvaged .5 g/cc Vermiculite Boiler bricks. Future stoves will utilize sawdust/clay/grog bricks (.67 g/cc) and HTM mortar made by Dedza Pottery.
- A 1.6 mm stainless steel inner skirt and a 1.6mm outer skirt. Wood ash placed between the 2 skirts for insulation. Future stoves will be built with 100% mild steel
- A removable shelf that is made from 4.5 mm stainless steel (which will be replaced by Cast Iron in future models).
- A hinged 12 mm round bar wood support.
- 20cm by 20cm combustion chamber entrance

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One retrofitted 250L Oil Electric stove

The electric oil stove (photo left) was one of 4 oil electric stoves that were donated to the Mulanje prison. These stoves cost an estimated US$ 3,000 each but were only in operation for a few weeks to a month before they broke. When no one was able to fix the

stoves, the prison administration went back to their traditional open fire.

In March 2003, we took the broken stove apart, salvaged most of the material, and rebuilt it as a wood fired rocket stove. Some new sheet metal was used for the combustion chamber but the new Rocket stove could be made, with time permitting, entirely from the used stove. At this point it has not been established if it is more viable for the prisons to retrofit the metal electric stoves or if they should just reuse the stainless steel cooking pot and build a new stove with brick.

The stove shown here was built in March 2003 with salvaged vermiculite boiler bricks. These bricks were set up with 5 parts High Temperature Zimbabwe cement, no sand, and 2 parts water. This mixture only lasted a few months. This stove was rebuilt with Dedza bricks and HTM Mortar in July 2004.
A heavier .9g/cc brick might be more suitable for a prison stove (for obvious reasons)

Two 2-pot Restaurant Stoves

One was delivered to Mulanje Motel and the other was left with Ken's Engineering as a demonstration model.

- Mulanje Motel Reported 90% reduction of fuel consumption as compared to open fire
- 7 mm gap between pot and stove body
- Insulated with Dedza sawdust/grog/clay bricks
- Suggested retail US$70-100

One Dover Replacement stove

This 2-pot +oven flattop stop was designed for Eastern Produce to replace the expensive and wasteful cast iron Dover stove. The new stove is currently being tested in an Eastern Produce manager's house in Mulanje.

- 12 cm by 12 cm combustion chamber entrance
- 30 cm by 28 cm by 35 cm baking compartment

Two 2 pot mud stoves

Built by Jayme Vineyard in cooperation with the women of Mulanje Boma

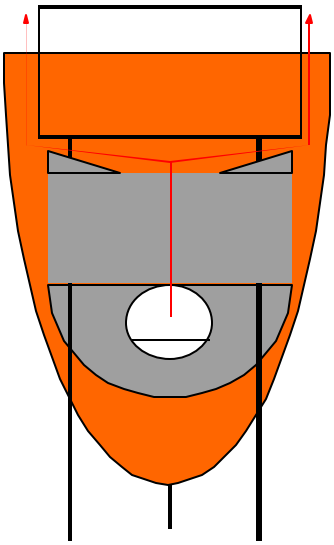
- Combustion chamber insulated with Dedza sawdust/clay/grog bricks
- Stove body built with anthill soil and bricks
- Shelves made from mild steel

- The pot sits inside the stove, thus increasing surface area exposed to hot flues gases.

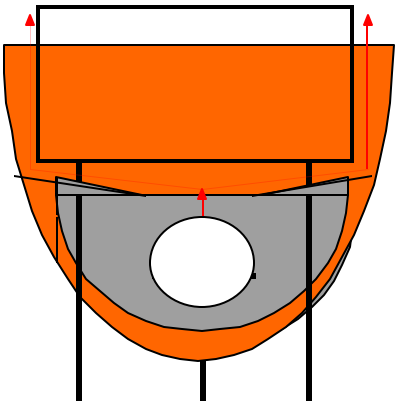
- 7-10 mm gap between pot and stove wall.
- These stoves were built in late July 2004. Mud stoves need at least 2 weeks to dry but

unfortunately Jayme and I were not present when the stoves were first used. Obviously training and testing of the stove is still necessary. This will take place upon our return in Jan 2005

Two New Portable Ceramic Rocket Stoves



- Made At Dedza Pottery
- The first stove is a full sized household rocket stove made from a terracotta body with a .67 g/cc sawdust/clay/grog liner (liner shown in gray)
- The pot fits inside the stove body. When the pot is placed inside the stove, a 7 mm gap is created between the pot and the sides of stove body
- The stove comes with two removable rings (not shown). The two rings nest inside of one another and then both of the rings fit inside of the stove.
- The straight black lines that extend downward from the pot represent three 12 mm round bar pot supports. These support the pot independent from the ceramic stove body and reduce stresses on the stove body.
- This stove is designed for optimum combustion and heat transfer efficiency.



- This Rocket stove is a shorter version of the previous stove and it is designed for optimum heat transfer efficiency, **not** optimum combustion efficiency. This stove, which is less expensive than the full size rocket stove, would be for outdoor use as it would be smokier than the taller ‘traditional ‘ rocket stove design.

- These two stoves have been ordered and will be ready for testing in Nov 2004

Brick Production

In March 2003, I visited Dedza pottery to discuss the possibility of producing insulative bricks for the Institutional stoves. Dedza pottery was already producing a relatively heavy .9 g/cc sawdust/ clay /grog insulative brick for use in their kilns as well as for the liner of tea estate boilers.

Their bricks are made in sawdust-powered kilns (see photo left). These bricks are rated to withstand temperatures up to 1300C.

The 100L and 200L institutional stove require a brick that only needs to withstand 1000C. The current 1300C Dedza brick is more robust than we require. More research is necessary before we can make a less expensive brick with lower temperature clay. In the mean time, however, the 1300C brick is more than enough to fulfill our needs.

Their current boiler bricks (see photo right) are .9 g/cc, which is heavier than out ideal .6-.7 g/cc brick. However we wanted to compare the durability of their heavier bricks so we worked with them to produce forty .9 g/cc 'heavier' bricks and seventy-two 'lighter' .67 g/cc bricks. These bricks were made with custom moulds that were produced in Mozambique. Measurements in cm

Qty	Mould Size	Type Clay	Clay Ref	Unit Pr.	Total
40	22 x22x6	Heavier	GIB/5	121.70	4868.00
48	16.5x33x6	Lighter	EKIB/3	164.56	7898.88
24	33x22x6	Lighter	EKIB/3	219.05	5257.20

US$1 = 109 Kwacha

Lighter brick recipe
22 parts sawdust (sifted through a #10 mesh)
3 parts grog (sifted through a #60 mesh)
7 parts high temp clay (sifted through a #30 Mesh)

Heavier brick recipe
7 parts sawdust (sifted through a #10 mesh)
2 parts grog (sifted through a #60 mesh)
3 parts high temp clay (sifted through 30 Mesh)

These bricks were then delivered in mid-July and were installed in the 2 mud stoves, the 2 modified WFP stoves, the 2 pot restaurant stove and the Satemwa Tea Estate 110L. The remaining bricks were used to fulfill the first WFP order for 55 stoves. The bricks form the 'L' shaped rocket combustion chamber (see photo left for partially built combustion chamber).

Since the first order (in Mar 2004) we have made some slight modifications to the combustion chamber dimensions. The combustion chamber opening is now 180 by 180 mm and the height is 470 mm. These new measurements required us to modify the brick mould. Note that the following are mould sizes and the final brick, after shrinkage, will be smaller. These bricks will be used to fulfill the rest of WFP's order for 55 Institutional stoves. Each stove requires 8 bricks. Measurements in mm

55 of 185x185x50
110 of 300x295x50
275 of 300x185x50
Total price: MK 85,959.23

Christa Messinger then repeated this order for WFP's second order of 55 stoves.

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55 of 185x185x50
110 of 300x295x50
275 of 300x185x50
Total price: MK 85,959.23

Peter Scott placed a third order in Aug 2004 to fulfill future ProBEC brick requirements
10 of 185x185x50
20 of 300x295x50
50 of 300x185x50
Total price: MK 15,628.95

A thirty thousand Kwacha deposit was placed as a deposit to cover these first three orders and the new portable household ceramic stove.

Brick Production

Way Forward

1. A lot of advance notice (2-3 months) is required when ordering bricks from Dedza Pottery. This should be considered when signing contracts for institutional stoves.

2. **The insulative bricks made at Dedza Pottery, are, as of Sept 2004, the best material option for the Rocket Stove combustion chamber in Southern Africa.** We should work closely with Dedza to develop new products. For example Dedza is currently experimenting with glazing the inside of the insulative bricks to increase their durability. If this succeeds this would make a cheaper and more durable stove.

3.
4. **We should contract Dedza pottery to teach others in Southern Africa how to construct sawdust fired kilns and make their special bricks**

5. Dedza has expressed interest in developing a joint research project with ProBEC. This should be explored further.

6. **We should encourage the development of sawdust/ clay/grog bricks throughout southern Africa, in areas that have access to the raw materials (Zambia, yes; Lesotho, no).**

WFP 110L Stove

Way Forward

55 stoves were ordered on July 30th and an additional 55 stoves were ordered in August. 55 Stoves should be delivered ASAP the second 50 stoves should be delivered 3 months after the first 55 stoves. This will give time to collect feedback from the first 50 stoves

and make any minor or major modifications that are needed to the stoves. In October, I contacted WFP in Llongwe and requested that they proceed with the dissemination as slowly as possible and to collect as much information from the initial stoves so that we can make modifications to future stoves in a timely manner.

We are still working with a new product in a new country and it would be optimistic to the point of foolishness to assume that we have made a flawless product the first time out.

1. A training plan for cooks needs to be developed and implemented. A laminated color brochure (see MangiMangi user guide) needs to be produced and placed inside each kitchen.

2. 1 week –1 month, after installation a site visit should be made to 10 of the schools. If problems are going to develop with the stove, or if the stove is going to be misused, it will generally happen soon after installation.

3. An additional follow up should be made to the same10 schools (as well as 10 additional schools) 2 to 3 months after installation. This feed back needs to be collected and sent to Ken's engineering in Mulanje and myself as well.

4. Each of the first 50 stoves should be marked. A steel plate marked with a production number will be used to mark the stove.

5. Based on criteria that were developed in August, Ministry of Energy will make an assessment of potential institutions that would be suitable for a Rocket Stove development program.

6. A cast iron shelf (not grate) needs to be made to replace the mild steel shelf that we are presently using. Contact EFC in Blantyre at 01 671 241or 01 672 028 for more info on casting the shelves.

Eastern Produce

Way Forward

Eastern Produce is still trying to decide how it wants to proceed with its stove program. They have been very satisfied with the work but are still not sure if they want to build brick or metal stoves. There are benefits to both designs.

For an organization such as Eastern Produce, **which is**:

- feeding large numbers of people (40,000/day)

- located in a relatively centralized geographical area (i.e. not spread out throughout the entire country- such as WFP)

And has:

- access to locally sourced and highly trained artisans and
- attentive management and quality control systems

I would recommend building a Brick Rocket stove as large as feasibly possible (200L+). For Eastern Produce I would recommend building the 200L + Brick stoves. Obviously for organization such as WFP, whose projects do not meet all of the above criteria, I would recommend building portable metal stoves that can be produced centrally and then transported to individual schools.

Ken's engineering

Way Forward

Ken has done an excellent job with producing the initial prototypes and is highly motivated to expand his business. To do this, Ken will need help with business planning

2-pot restaurant stove

Way Forward

On July 28, 2004 I interviewed Henry, the owner of the Mulanje Hotel and he stated that his daily fuel consumption was (US$1= 109 Kwacha):

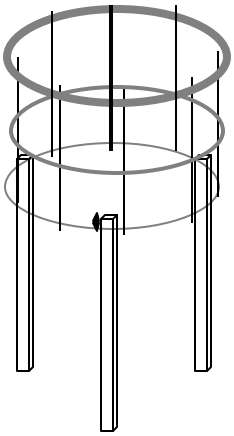
2 bags charcoal @ 180 Kwacha/ bag	360K/day
approx 5 bundles of firewood	100K/day
Total	460K/day or US$1,540/year

Initial feedback from Mount Mulanje hotel indicated 90% savings with the 2-pot stove as compared to the open fire. As can be see from the above data, however, the majority of the fuel costs are for charcoal, not fire wood. Some tasks that are currently utilizing charcoal could use firewood whereas some absolutely require charcoal. For example, cooking chips can be done with wood but roasting of meat is inconvenient with a Rocket Stove. A research and an education component is essential so that we can explore how much restaurant cooking can be switched from charcoal to the Rocket Stove.

100 L Brick Stoves

Way Forward

All Brick institutional stoves should now be built with this internal steel skeleton. This structure supports the pot, maintains the proper 15 mm gap between the pot and the stove body, and decreases stress on the brick stove body



100L Double walled stove

Way Forward

This stove is not currently installed in an Eastern Produce estate kitchen, as they are satisfied with the brick 100L and the metal 200L. If this stove goes unused for a long period of time, perhaps ProBEC could coordinate with EP to install it in another location, such as a school in Mulanje.