Introduction of Rocket Stove Cooking Devices (Household Stoves, Bread Ovens and Institutional stoves) into SADC Region

Lesotho
Hillcrest/KwaZulu/South Africa
Mozambique

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Draft Report

Presented by Peter Scott/Aprovecho

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1.0 Terms of References

Three SADC countries - Lesotho, South Africa (KwaZulu/Natal) and Mozambique - were chosen as target countries for Rocket Stove dissemination.

1.1 Lesotho Sept 14th- Oct 28th

The original Terms of Reference specified 2 goals (later expanded to three) for Lesotho:

1. To work with the World food Program, Ministry of Education and local schools to design, produce, and disseminate 2 unique fuel-efficient cook stoves to support WFP's school feeding programs.

2. To redesign the household Rocket stove (known locally as the Nkokonono or 'big man') that was introduced in March 2003. The goal was to increase its durability and increase its consumer appeal, with the intention that artisans throughout Southern Africa could then easily reproduce the design.

3. During the last 2 weeks - due to requests from Local Government and ATS staff members - it was decided to expand the TOR to include design work on a portable bread oven that would be used in rural communities to generate income and increase food security.

From Sept 14th to Oct 28th, **7 new cooking prototypes were introduced into Lesotho**. These stoves were original designs that were built using Rocket Stove principles created by Dr Larry Winiarski and Aprovecho Re search Center . The stoves were designed and built in cooperation with the staff of the Appropriate Technology Section (ATS) of Local Government, the consultant and Jayme Vineyard.

2.0 Materials Outputs

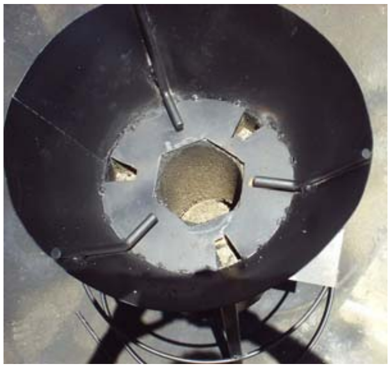
48-loaf bread oven
The oven is made from 1.2, 1.6mm and 2.0 mild sheet steel, fired insulated ceramic tiles, and vermiculite. This stove is presently being remodeled by the staff of ATS to accommodate a larger bread pan.

<u>3 versions of the Household Nkokonono Stove were built</u>

Nkokonono Mk1
The original Makotekote Nkokonono- designed in collaboration with Michael Hones in March 2003 - utilized recycled tin cans to support the 6 brick VIC (vernacular insulated ceramic) combustion chamber. Although there are some questions about the durability of this version- the tin cans around the mouth of the combustion chamber degrade in a few months- there is still interest in it due to its low cost, simplicity, and unique aesthetics. This stove retails for approx 120Rand.

Nkokonono Mk2
The first modification of the original Nkokonono also incorporated used tin cans as a lightweight structure to support the insulated bricks. To increase the durability of the stove, the cans were placed inside a1.2 mm sheet metal shroud. This model was later **discarded** because it used more sheet metal than was necessary and would have been difficult to replicate in areas where used pop cans were not available.

Nkokonono Mk3
This version has the same general geometry as the Mk2 but discards the tin cans and reduces the amount of sheet metal required. To support the stove body a stand is required. The stand is relatively inexpensive (20R) and can be built at different heights to suit the cook's needs. With metal purchased from Bloomfontein (South Africa) the material cost for the stove body drops to approx 50 Rand (approx US$7).



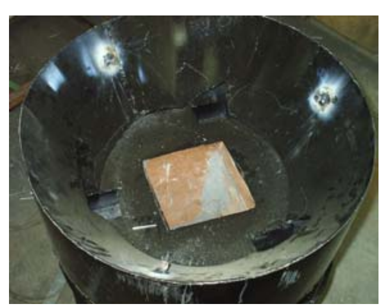
Nkokonono MK4
This is exactly the same as the Mk3 except that it incorporates the less expensive cement vermiculite monolithic combustion chamber. This version needs to be field-tested before large-scale production can begin. Until then, the Mk 3 is still a viable alternative for production.

<u>Three versions of the Nkokonono Poloko Stove were built.</u>

Nkokonono #25 Mk1
The first Nkokonono Poloko was built as a modification of the Ugandan Institutional stove that the consultant designed in Uganda in August 2003. This stove was modified to accommodate the traditional three legged cast iron pots. This design was discarded as it proved to have a number of shortcomings (too heavy, too expensive) and was not suitable for cooks in Lesotho

Working with the team at ATS we were able to design a more suitable design that was cheaper, shorter and lighter than the original.

Nkokonono #25 Mk2
The new stove is considerably lower (about half the height), half the weight and a third of the price (retail : 800 -1100Rands). It has a cone that maintains the cross sectional area around the bottom of the curved pot, and has three 'boots' which allow the bottom of the pot to be lowered to 4.3 cm above the top of the combustion chamber.



Nkokonono #20 Poloko
A second Poloko stove was built to accommodate # 20 pots. This stove was built around a 220L drum. Fortuitously, when the pot was placed inside the drum it created the optimal gap between the pot and the stove body. Material costs for this stove are considerably cheaper (approx 300Rands) but more feedback is necessary to ascertain whether the stove is appropriate (too tall?) for local cooks.

3.0 Site Visit

During our first week in Lesotho we accompanied Vivienne Abbot on her visit to the plateau near TY to assess the acceptability of the cooking devices that were placed in April 2003 (Nkokonono Mk1, 2 kinds of solar cookers, and the Vesto stove). Of the 7 households we visited, 4 houses had received the Nkokonono. All of the families were in the process of cooking with the stove upon our arrival. It is possible that they were aware we were coming, and decided to fire the stove to appease us. This is possible - but unlikely - as it was an unplanned surprise visit. The households were using 4 fuel combinations in the Nkokonono:

- wood
- wood and agricultural waste,
- wood and dung and
- agricultural waste

Although people appeared very pleased with the stove as demonstrated by their comments and the high level of adoption, there were a number of problems, some of which were due to design error and others that were result of improper construction techniques. First, **the gap between the combustion chamber and the pot was not optimal**. This dimension was apparently not   communicated to the builders during my brief visit during Mar of 2003. The new designs now have the correct gap. **The stove shelves were not the correct height**. This led to improper airflow and rapid air channel clogging. **The shelves were removable which led to improper usage** (the shelves were placed upside down, placed too far inside and/or not far enough inside the combustion chamber). This will be addressed in future models that will have a fixed shelf.The popularity of cooking with low density fuels such as dung or

agricultural waste meant that the **combustion chamber was filling with ash much faster than with high density fuels such as wood**. The new design will have a deeper elbow that will provide more space for the ash that accompanies low-density fuels. Although the VIC combustion chambers were still functioning (some of the bricks did have cracks) they were **degrading at the top of the combustion chamber where they were interfacing with the pot legs**. Later designs incorporated a combustion chamber cover to protect the insulation and slots to better accept the three legs. And finally, **the tin cans were degrading wherever the flames were contacting them** (notably at the top and at the mouth of the stove). Later models are made without tin cans but the issue of flames on bare steel still needs to be addressed by better insulating the skirt and the fire flow path.

3.1 The Vesto Stove

Of the three houses that we visited that had Vesto stoves none of them were in use and they had the appearance of being minimally used. One woman had given her Vesto to a neighbor who had tried it but was not particularly interested in the stove. It was unclear what was the root of their dissatisfaction although one would suspect that it was due to its incompatibility with the traditional cast iron pot.

3.2 The parabolic solar cooker

Although very popular -many of the women seemed intent on buying the cooker, even at 800Rand - nobody was actually using it when we arrived (to be fair, it should be noted, that it was only a partially sunny day). Perhaps the women desire the stove more for its status enhancing quality than its ability to cook food. Furthermore, the women, who said that they were using it, were using as a way to conserve gas or electricity, not wood. So even though it has value as a cost saving measure, it probably has limited value as a Biomass Energy Conserving device. In fact the cookers high cost might actually absorb funds that could be used for an improved stove.

4.0 The Rocket Bread Oven

Constructing the bread oven

These pictures are meant to accompany the improved AutoCAD drawings that are being updated by ATS.

This is the outer shell and the combustion chamber of the bread oven.

The lower part of the bread oven is built with 1.2 mm mild steel.

This thinner metal can be used because it will be covered with the insulative cement vermiculite mixture. Pictured here is the fired clay/vermiculite brick, which will be replaced with the cement vermiculite mixture in future models.

The upper part of the bread oven shell should be constructed with 1.6 mm.

A 3mm mild steel diffusion plate is placed above the combustion chamber.

Coarse Vermiculite Insulation is placed around and on top of the bread oven annulus.

The cover is then placed on top of the insulation.

Note the angle iron struts that are placed above and on either side of the combustion chamber to support the baking compartment. This supports the baking compartment and allows for easy insertion and removal from the out shell.

The baking compartment (2mm mild steel) is then inserted into the baking shell. Note the 2 cm gap on either side of the bread oven and the 4 cm gap on top of the bread oven.

The detachable face plate (which allows for easy removal, maintenance, and repair of the baking compartment) is attached. Hinges are welded on to the insulated doors, and the stove is painted

Clay tiles are placed on the floor of the oven to moderate baking temperatures between door openings

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A sliding guillotine door on rails is attached above the fuel magazine/feed chamber. This door is used to reduce airflow after the oven has reached baking temperature.

4.1 Rocket Bread Oven assessment

During my last week in Lesotho Michael Hones and I had a long discussion about the bread oven and we both agreed that, in hindsight, it might have been better not design the oven, as it has the potential to increase wood consumption in Lesotho's rural communities. I probably should have been more cautious when I was approached for a bread oven design. However, in the end, I doubt that it will have an overall negative impact on the local environment.

Here is the bread consumption situation in Lesotho as far as I understand it. At the moment people are not cooking bread commercially with wood in the rural areas of Lesotho. However people *are* cooking bread at home using inefficient three stone fires. If these people purchase bread that is baked in the Rocket Bread Oven then this will hopefully offset the wood consumed by the Bread Oven.

However, without an elaborate baseline study, we can't say whether the Bread oven will result in a net loss or gain in biomass, so for this reason I agree that we should **avoid actively promoting the oven** in Lesotho

During the final stove partner training that I held at ATS I tried, as strongly as possible, to dissuade ATS from promoting it, explaining that we, ProBEC, are in the biomass conserving business and not the stove/oven/bread baking business. Not surprisingly, this plea fell on deaf ears.

4.2 The way forward

I think all we can do at this time is to try to make the best of a less than ideal situation: ATS is going to promote the oven whether we like it or not. What we can do is a) not put any energy into disseminating the oven and b) ensure that it is as fuel efficient as possible. Whatever R&D ATS wants to perform on the bread oven can be applied to our bakery work in other SADC countries that bake bread with wood and face a fuel wood shortage.

To this end, research can be performed to improve the oven. A proofing oven can be attached to the oven. Baking tests should be performed so that users can be taught correct oven operation: e.g. correct quantity of fuel to be used, firing sequence, the correct door position to limit air flow into the stove after the correct baking temp has been reached etc…

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These tests should monitor exit temp to assure that only the amount of fuel that is needed for baking is placed in the combustion chamber. The correct exit temp, measured from inside the base of the exit chimney, is approx 180 degrees Celsius.

The problems that we faced in regard to the creation of the bread oven highlight the fact that Lesotho is a challenging ethical environment for stove design.

We are faced with a similar challenge when confronted with the request for a heating or cooking /heating stove for Lesotho. Will an inexpensive and efficient heating stove actually reduce total fuel consumption or will it just allow them to burn the same amount of wood (or more?) than they burn in the traditional Paola. An improved stove might allow them to heat their homes over a longer period of time, thus improving their comfort level, but would not meet our goal of BEC. As you might be aware, it is not uncommon for some Basotho to use their electric space heaters even in the middle of summer!

I think the answer to this problem is, to try, wherever possible, to put our energy into building stoves that don't have these kinds of ethical dilemmas attached. In other words, lets not put any more energy into bread ovens and heating stoves in Lesotho until we have solved the rest of SADC's more pressing biomass problems.

5.0 The Household Nkokonono Mk4

Cement Vermiculite Combustion chamber
(Note the 1.2mm ms drum shown here has a square opening, however a circular opening is recommended to accommodate the PVC pipe)

The basic recipe for the cement vermiculite insulation is

- **One litre of coarse processed vermiculite** mixed with
- **170g of cement** then add
- **290 g of water.**

It is imperative to add the water after mixing the cement and vermiculite. This mixture should not be tamped, but lightly placed inside the form. It should be dried for a minimum of 3 days in the shade and 7 days in the sun.

The volume of the combustion chamber dictates the volume of vermiculite needed