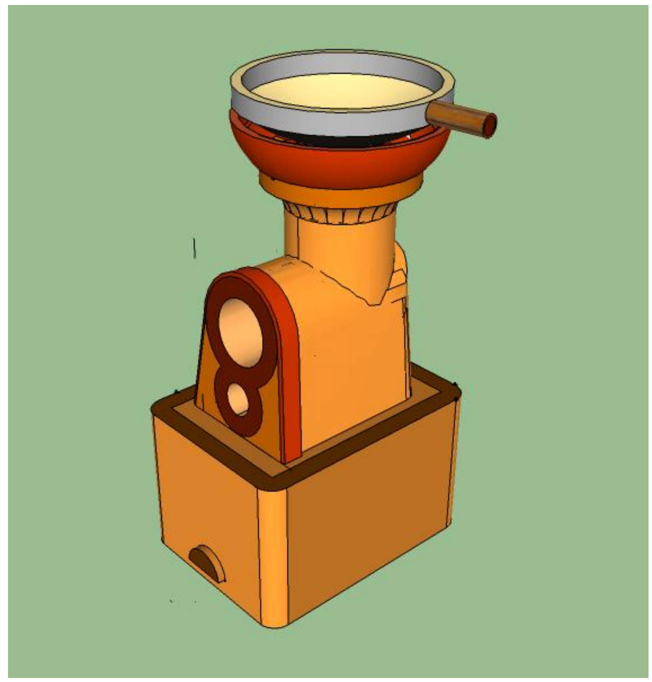
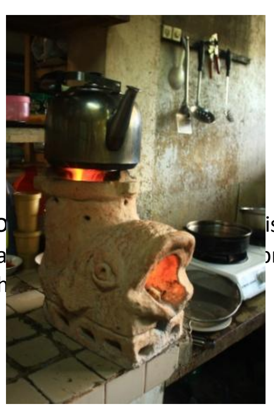
The Holey Roket Stove with Char Pocket

A Prototype Fabrication Project

1. Introduction



From 2009 to 2010, I have been deeply involved in my practice of learning how to make the holey roket stoves and the holey briquettes. I received generous support from Rok Oblak for the stoves and then from Richard Stanley of the Legacy Foundation for the briquetting lessons. With very meager resources and sheer perseverance, I was able to make several models of stoves and was even more inspired enough to discover my talents in infusing arts into the function. And then, sometime in September 2012, with lessons on gasification from the website of Dr. Paul Anderson and handbooks from Professor Alexis Belonio, I discovered that the holey roket stove (HRS) can be fed with pili shells and used as a TLUD gasifier stove. After pouring about one liter of the shells into the fire chamber and partly in the fuel feeder, I lit it up from the top. With a gentle blow of air through the fuel feeder, a beautiful yellowish clean flame came off dancing at the top. Although I understand that I still have to seek the confirmation of the experts on this claim, I have in fact been using the HRS with pili shells for almost six months until now. Broken coconut shells may also be used with the same technique but is more difficult to control. From then on, it has been our practice in the house to use pili shells as our primary fuel until now. We can continuously cook in this manner by pushing in more shells into the fuel shelf with a pusher rod.



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The pili (ovarum canatum) shell is an excellent kind of fuel. I pour the shells on the stove leaving about 2 inches from the brim and then light it up from the top. It then gives a clean strong flame. Photo at extreme left shows the holey roket stove in a shape of a fish and cooking with pili shells. Photo at right shows the raw pili shells and the carbonized shells after cooking.

After cooking, I harvest the char by pulling them with a stick and keeping them in a tight metal cooking pot. As soon as it is cooled, a very tough char is produced. However, this process has its inconveniences and to some extent risks. Pulling the hot char from the fuel chamber presents risks of burns and worse, open fires.

During the March 18-22 GACC conference at Phnom Penh, Cambodia, I showed photos of the stove with this practice both to Dr. Paul Anderson and Dean Still of Aprovecho Institute. However, both experts could not give a confirmation by simply looking at the photo. Nevertheless, I actively participated to all sessions and invited myself to the smaller breakout sessions. One emerging agenda among stoves designers is the call for charcoal making stoves.

More challenges in the biochar making stoves are presented in the study by Sarah Carter and Dr. Simon Shackley of the UK Research Center of the University of Edinburgh. Their research entitled **Biochar Stoves: an Innovation Studies Perspective** gave extensive discussions on the char making properties of four stoves namely the Anila, Everything Nice, the Sampada and the TLUD. It also presented a detailed set of description of the challenges that each of the stoves. It concluded with the challenges that such stoves promised reduced fuel consumption and reduced smoke emissions. The study also presented the limitations of the four stoves on test such as flame control, use of a wide variety of fuel and continuous cooking. It did not however investigate the length of the usable life of the metal stoves.

With all the debates and emerging agenda in the stoves sector, I was compelled to drop in my own contribution. In total contrast to char consuming stove, this will be a char making stove which will try to fill into the gap between the challenges of cost, flame control, continuous cooking, stove life, aesthetics, and ownership. In the end, I hope to get support for this project in terms of testing, improvements, and manufacture and popularization.

2. **Objectives of the Project.** This project hopes to

- Determine the technical performance of the stove prototype.
- Determine its char making properties
- Determine the user responsiveness of the design.
- Generate lessons and renovate accordingly.
- Solicit support for further improvements and eventually manufacturing.

3. **Research Questions.** The project would like to answer the following questions;

- What will be the technical performance of the stove? Will the char harvesting component (side pocket and char box) not affect the technical performance of the stove?

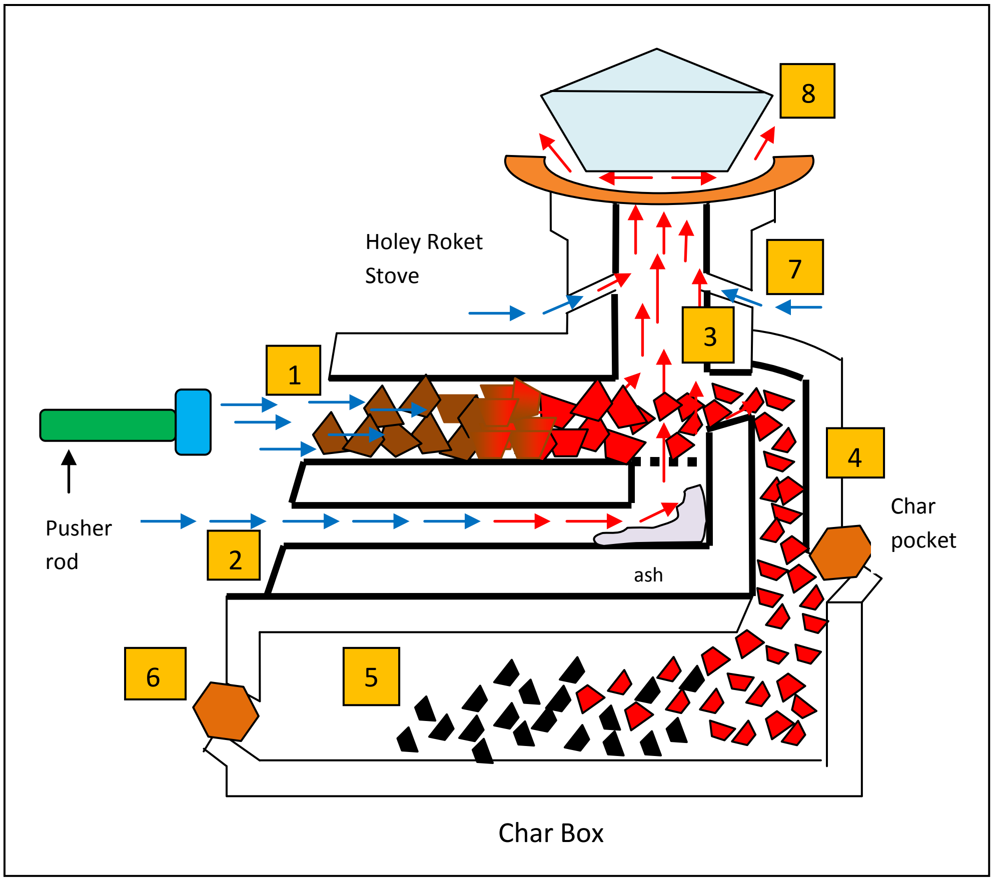
- Will it be able to cook from different types of fuel that is from wood sticks, shells, wood pellets and holey briquettes and produce char at the same time?
- Will the stove produce char without the risk and inconveniences of open collection?

- Will it produce highly dense char with less ash? What would be the fuel – char ratio that the stove produces? Will it be good as a biochar for soil and water filtration?

- Will the components be durable enough? How long will it last with intense use?

o Will it overcome the difficulties defined by the users in the Carter-Shackley study namely flame modulation, wider options for fuel, continuous cooking, harvesting char and price?

The Holey Roket Stove with a char box as drawn and as built and now drying. Notice the pusher rod (center photo) and the char pocket (upper right photo) on which a can of sardines may fit at the cover and the char box (lower right). Another possible plug would be plaster of paris but should be built only after the stove was fired in the kiln to ensure a tight fit. .



The diagram above illustrates the flow of air, hot gases and char in the stove unit.

1. Fuel is fed at the extended fuel shelf. The same fuel shelf can also hold wood sticks and holey briquettes. Shells and pellets may be pushed by a pusher rod. This will promote the balance between the air and fuel.
2. Additional primary enters the second barrel beneath the fuel shelf. Incoming air is preheated and meets the fuel and hot gases at the combustion chamber.
3. Char is produced at the pyrolysis zone. Ash falls down through the metal coil grate. Hot char may be pushed off with a metal pusher rod through the port hole at the back side of the stove.
4. Hot char falls along the char pocket and falls further towards the char box. The small port is meant to allow a rod to push down clogged chars if necessary.
5. The hot char while deprived of air cools down. Heat is absorbed and stored in the char box and stove floor which may help in the next cooking session.
6. The cold char may be pulled off with a stick.
7. Secondary air enters the hole. For this project, I poked a hole through the stove body in a inclined direction pointing upwards. All the holes further converge to a concentric circle. The purpose is to create a twisting motion of the hot gases to improve air mix.
8. Hot gases escape along the walls of bowl skirt and the kettle.

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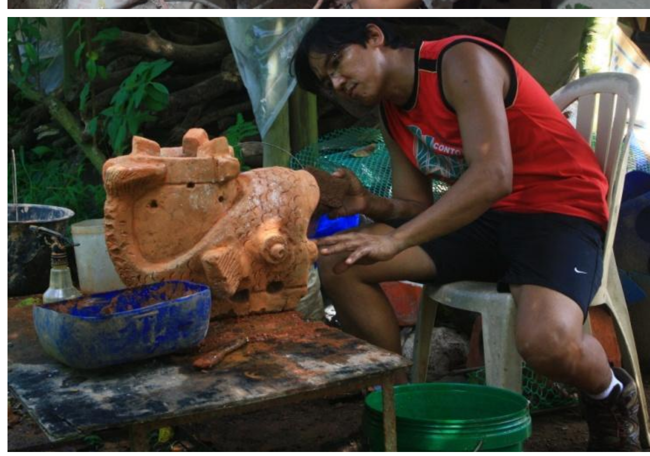


4. **Features of the Stove**. To respond to the research questions, the stove will have the following features:

4.1. **It will allow continuous cooking**. It features a side fed fuel chamber which will allow the user to add fuel chamber at any point while cooking.

4.2. **It will allow better flame control.** The first feature connects to this requirement. The flames can be increased by (1) adding more fuel or (2) adding forced air with a fan or compressed air canister. The flames can be reduced by (1) reducing the fuel, (2) pushing the hot char into the char pocket and (3) covering the fuel feeder with a metal sheet.

4.3. **It will eliminate risk of handling hot char**. The stove will not require tilting and pouring of hot canisters. The user will simply have to push the hot char into the char pocket while cooking with a pusher rod. The hot char will fall into the pocket and/or into the air deprived char box and stay there until it is cooled.

4.4. **The stove will allow more types of fuel.** It can be used as a rocket stove and be fed with wood sticks and holey briquettes. It can also be used as a TLUD with shells as well as wood pellets and with an option of forced air or natural draft. Please see Annex 2.

4.5. **It can be produced with less cost**. It is expected that the production cost of the stove will not be more than $ 8.00. For people with access and skills working with clay, the cost will even be negligible.

4.6. **It will stimulate employment and promote social inclusion**. Clay stoves create more employment than metal stoves. It invites people with access to clay and practical skills to open up their own village enterprises at much lesser cost than the equivalent metal stoves.

4.7. **Allow longer stove life.** Although clay stoves are heavier and brittle, it will outlast its equivalent metal stove. The longest model still in use by a client is already **three years old** and is still very much in use.

5. **Components.** To comply with the expected features, the stove will have the following components.

5.1. **Extended fuel shelf.** While the other more popular model have taken off the long snout of the rocket stove such as the EnviroTech and EnviroFit, I decided to preserve it for the following reasons;

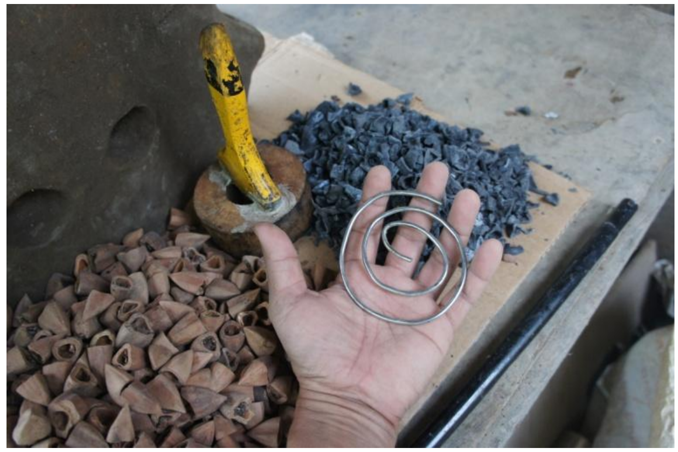
- The fuel shelf is much cheaper to construct that the equivalent metal grill. It can be constructed with additional clay.
- While this stove can hold wood sticks, it will also hold holey briquettes and fuel pellets where stoves without snouts cannot.
- It will promote pre heating of the incoming primary air and fuel.
- To allow more primary air into the fire chamber, I added four more holes on the side of the fuel shelf and several more on the lower portion of the fuel shelf.

5.2. **Char Pocket.** During continuously cooking, there will be a build up of hot char inside the fire chamber. This will clog the fuel shelf. The trick is simply to push the char with a long metal rod until it falls into the char pocket that was fixed at backside of the stove.

5.3. **Char box.** The hot char will fall all the way down into the char box. The box is tightly closed without incoming air thus harvesting well made char is possible. Furthermore, it will also prevent risks of burns and open fires. Finally, it will serve as a platform for the stove to allow better reach for the user. Meanwhile, women who prefer to sit on the ground while cooking will have an option not to fix the stove over the char box.

5.4. **Pusher rod for fuel**. It is made of a flat piece of wood fixed to a handle. For this project, I cut a worn out wooden plunger from my briquette press machine. Then, I fixed it to a worn out handle of a paint brush with glue. It then makes an excellent pusher rod for granular fuels such as shells and wood pellets. Pushing these type of fuel promotes the correct air to fuel ratio thus maintains gasification.

5.5. **Pusher rod for the char**. Unlike the previous pusher rod, this metal rod will push the char into the char pocket.



5.6. **Metal coil.** This allows inflow of the primary air from the second barrel beneath the fuel chamber. For this stove series, I am using an 8 mm stainless metal rod which I form into a coil using pliers. This technique eliminates the need for welding.

5.7. **Forced air fan.** As Josh Kearns argues, TLUD stoves will produce higher quality char with TLUDS at higher temperature which is a function of higher draft. An air fan may be fixed at the opening of the snout to increase the draft and thus produce higher temperatures. An alternative for people without access to electricity would be a compressed air in a canister. A hand pump may be used to push in air in a canister (or a rubber tyre). This will be the subject of my next project.

5.7.1. **Expected Outcomes.** . This project, if successful will support the following.

- Production of char for the char consuming stoves as a livelihood enterprise
- Supply of bio char to help improve food gardens
- Supply of bio char for water filtration
- Contribute to the overall goals of the clean cook stoves sector in cleaning indoor air and preserving the forests.
- A series of skills training programs for community organizations to produce stoves artisans.

6. **Status of the Project.** As of this writing, I have already built the stove and the char box and now drying in my shed. The entire unit is expected to be tested within the coming two weeks or as soon as has been fired in the kiln.

7. **Needs.** There would be three major help that this project would need.

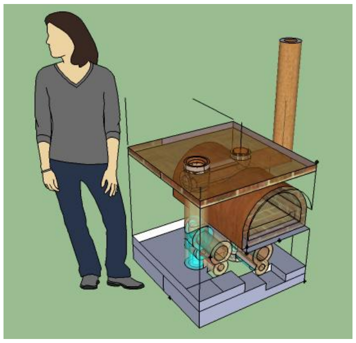
7.1. **Mentoring.** I would like to seek help in (1) refining the design of this project.

7.2. **Laboratory Testing.** The stove prototype needs to be tested in laboratory with the appropriate testing protocol to determine its capacity to comply with the expected performance measures.

7.3. **Cooking Tests.** It will also have to be tested in actual household use with several households over a considerable length of time to determine its user responsive parameters. Going further, it may have to be tested along with other stove models.

ANNEX 1.

My newly built 4n2 stove oven is now in full use in my kitchen. It was inspired by the earth oven designed by Jon and Flip Anderson of the Recho rocket stove series. It features three (3) cooking ports and an oven.



My 4n2 stove oven as planned, built and used. I used mostly bricks that I made and partly I bought at the hardware store. One of the stoves can serve the three cooking ports and the second stove will serve the oven. It took almost three months of drying until we finally inaugurated this project on February 2013 with a very yummy pizza which my daughter Mirasol prepared and enjoyed.

The stoves are fed with all types of biomass fuels such as wood sticks, holey briquettes and pili shells. I can regulate the flames by adding more fuel. Pots for simmering are transferred to the low heat port while pots for fast cooking sit on the high heat port.

The oven has to be preheated for about 45 minutes. Pizza can be cooked in about 12 minutes. All cooking ports including the oven can be used continuously as raw fuel can be added on the fuel shelf.

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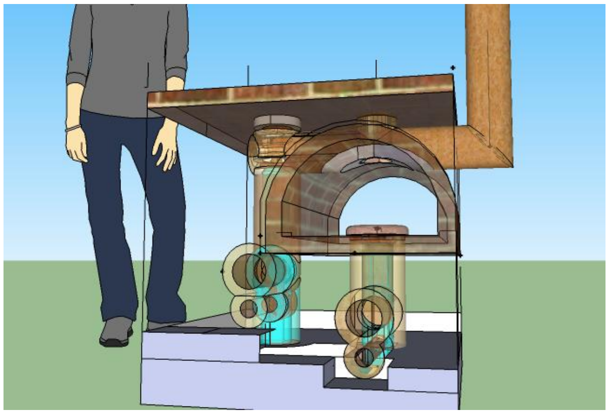 

The oven chamber features the holey roket stove beneath the oven floor, a clay disc to deflect the hot gases sideways and unto the walls of the oven, an extended metal cylinder at the chimney. The combination of the two deflectors (the disc and the cylinder) causes the heat to circulate inside the chamber thus give a more uniform and retained heat. My thanks go to Jon and Flip Anderson and Larry Winiarski for the lessons I gathered from their earth oven stove.

ANNEX 2.

The following are excerpts from the **Biochar Stoves: an Innovation Studies Perspective. Sarah Carter and Dr. Simon Shackley, UK Biochar Research Centre (UKBRC), School of GeoSciences, University of Edinburgh. 8th April 2011.**

More specific feedback about the stoves included the following points:

- in some cases, the height of the stoves was inconvenient, e.g. for Indian women who prefer to sit on the ground to cook (the Anila is the tallest of the test stoves);

- there was no easy way to add more wood into the stoves while the pot is on, since the gap between the pot and the stove restricts the size of wood which it is possible to add in;

- this 'batch' approach compares unfavourably with the 'continuous' fuel feed of other conventional and improved stoves since the user does not know precisely how much fuel is required prior to the cooking process and can end up using too little or too much fuel, the first introducing inconvenience and time delay and the second ending up waste fuel (and increasing biomass extraction and wasting time in collecting fuel);

- gasification stoves require reasonably small and uniform pieces of biomass, hence limit the use of certain feedstocks such as larger sticks, reducing overall fuel use flexibility;

- the ability to alter the intensity of the flame was limited, so reducing the flexibility that cooks value;

- it was difficult to remove the ash / charcoal from the stove without turning the stove over, so a way of emptying the stove could be made (which is achieved in some stove designs by having a trap-door arrangement, [11]);

- those with large families struggled to cook effectively with large pots on these particular stoves;

- the two lids of the Champion TLUD made it more difficult to handle, so these could be joined together;

- the EN stove needed a draft and a grate – alternatively, larger holes in the fuel chamber would help to keep the stoves lit.

For those that would buy the stoves, the price they suggested they would be willing to pay for the stove ranged from 2.22 USD and 25 USD, with the averages given in Table 7.

In summary, while the stoves tested do appear to meet some of the objectives of an improved stove (reduced fuel consumption, reduced smoke production), the users also noted some limitations in their functionality compared to their conventional primary stove. Better **flame modulation, fuel flexibility and ease of fuel addition** can all make women's cooking tasks much easier on a daily basis and the 'improved' gasification cook-stoves turn out not to be as adequate as conventional stoves in these regards.

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