Anatomy of the PapaBrick Stove

Designed and Fabricated by Joshua Guinto (Jed)
Philippines
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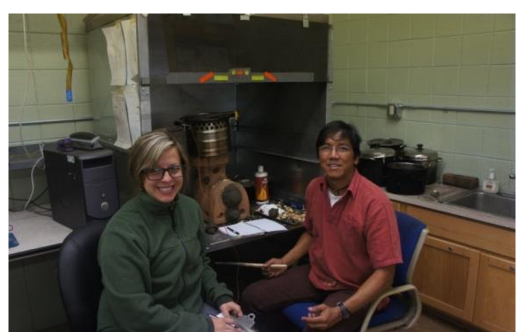
1. **Background.** The PapaBrick Stove was designed to cross over the limitations of the rocket stoves and the TLUD stoves which are batch fed and made of metal. Between 2009 to 2015, I was jumping between fabrication of rocket stoves made of clay and TLUDs made of metal. With Rok Oblak acting as my primary mentor (plus more advice I got from the stove list serve)

From 2009 to 2013, I built several models of the holey roket stoves with additional features of a secondary air barrel below the fuel shelf. This second barrel also serves as an exit point of ash and char whenever the elbow gets clogged up. The stove works excellent with holey briquettes. Households in the project areas where it was introduced attest that they were able to cook a kilogram of rice with two briquettes plus a few sticks of wood thus a savings of $.08 for every meal. The stove was fixed with secondary air holes on the chimney of the roket and observed some stove behaviors that made gasification in the holey roket possible. And in some of the cases, did some sculptures over it.

On 2013, I built several unit of the Estufa Finca. Majority of the advice came from Art Donnelly of Sea Char and then more from friends at the stove list serve (the list is very long). I purchased a batch type rice husk gasifier from Engr. Alexis Belonio and learned more about TLUD gasifiers. Finally, I participated in the Aprovecho Stove camp at Oregon in 2014.

One of the many important feedback I got from the women who were using the holey roke with wood sticks was about the stability of the flames. The flame would too frequently go out when they neglected poking the stick forward. It is because they would be busy doing other chores in the kitchen other than cooking. At Aprovecho, this limited firepower of my holey roket was confirmed during the lab test. *(I only did one test on wood chips. I should have tested it with holey briquettes and pilinut shells for several rounds so then I could have better results).*



The holey roket in the hood at Aprovecho.; Jed with Jesse, one of the Interns in the lab.

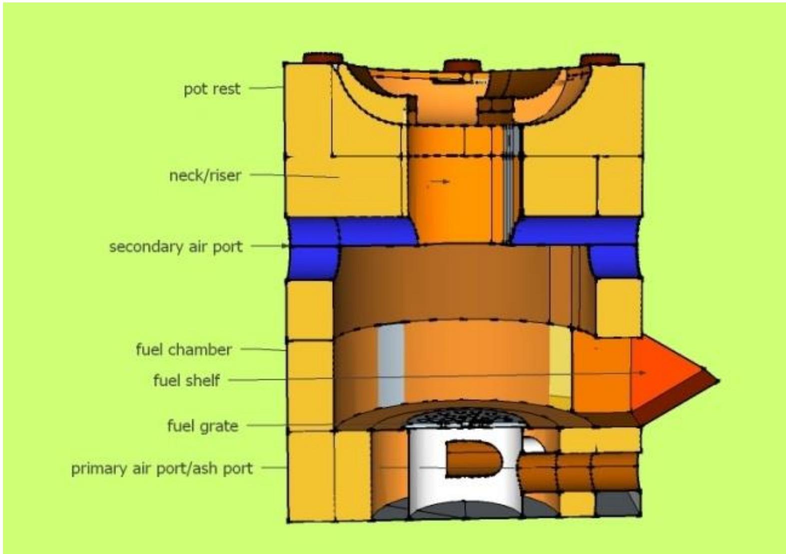
Designing from Feedbacks and from the Stove Camp. The lessons I got from the Aprovecho Stove

Camp helped in finally creating this model now I call the **PapaBrick Stove.** The name has roots from my own language "***patung-patong***" which means placed on top of one another like a Lego Toy.

During the last quarter of 2014, the stove began as a bigger model which I already introduced to the communities of Eastern Samar during a skills training. The stove was too big for a small household and cannot be moved elsewhere. A few months after I decided to create a smaller kitchen version with twenty one brick pieces. Twenty one brick pieces takes too much time to fabricate. Finally on July 2015, I decided to create it only from nine brick pieces.

The PapaBrick Stove during the early days of prototype development (top left) October to December 2014. The stove fed with pilinut *(canarium ovatum)* shells, the best kind of fuel for this stove.

What I had in mind was to overcome the design limitations of the holey roket and the Metal TLUD Batch Fed stoves and to come up with a hybrid. The following table describes the comparative design features.



The PapaBrick Stove with its component parts.

Comparative Parameters and Design Features.

Parameters and Design Features	**Holey Roket**	**Metal TLUD Batch Fed**	**PaPaBrick Stove**
Fire power	The elbow does not allow bigger load of fuel. The stove requires much attention in tending the flames. The sticks will have to be pushed in too frequently. This discourages the cook, mostly women who have to attend to other chores in the kitchen while cooking. The stove gives better performance with holey briquettes. Three briquettes in a row give a good start.	There is a quick hot start and intense fire power.	The fuel chamber comes from the shape of a Buddha belly where the expanded chamber allows more than twice the amount of fuel loaded. The fuel chamber then constricts at the riser. The riser serves to create the natural draft and at the same time as a mixing point of the gases. The stove begins at a TLUD mode and it quickly gives off a very intense flame at the beginning.
When fire goes out. *(is this also the turn down ratio?)*	Once neglected, the flame goes out too quickly. Getting the flames to start again is very discouraging.	With the hot char bed, restarting the flame is very easy.	With the hot char bed, restarting the flame is very easy.
Secondary air	Preheating of secondary air is very limited. In 2014, I built secondary air holes on the chimney on the holey roket stove. But the length of the air passage is limited only to the cross sectional thickness of the stove wall. Furthermore, I was anxious that this might reduce the draft effect of the chimney.	There is pre heating of secondary air all the way in between the two canisters; two canisters are required.	There is pre heating of secondary air. There is only one stove wall but the brick stove wall was built with a series of tubes running through. Cold air is pulled in from below the stove wall and then is heated up as it rises through the tube. It would then shoot into fuel chamber just before the riser and mix with the flammable gases. Constructing the tubes is simply pushing in metal tubes unto the clay walls while the clay is still wet and soft. The exit tubes were built off tangent angle to the center which gives the jets of air a

			twist thereby creating a vortex. This extra swirl adds to the mixing of the gases and to the time to complete the combustion.
Continuous feeding and reloading.	The stove was designed for continuous feeding. However, the elbow may be clogged with ashes during extended period of cooking. The ashes or char may be pulled out through the second barrel beneath the fuel shelf.	Continuous feeding is not possible. Reloading the stove should only be done after it has cooled down.	The fuel shelf on the side allows continuous feeding. However, this has to be done under several conditions. (1) The side fuel shelf must at all times be fully loaded with fuel. This will reduce the entry of too much primary air which is cold. (2) Continuous feed should only happen after the cold start is done that is, when all the first load of fuel is consumed and there is enough hot char bed in the chamber. By being hot enough the incoming fuel from the side port will gasify sufficiently. (3) the side fuel must not be poked too deeply.
Harvesting the char.	The stove need not be tipped over to unload the char. Instead, the char is scraped off at the bottom of the stove. Bit by bit, it will have to be poured unto a metal pot and then covered.	Harvesting the hot char is dangerous. The entire stove must be tipped over to pour out the char.	The stove need not be tipped over to unload the char. Instead, the char is scraped off at the bottom of the stove. Bit by bit, it will have to be poured unto a metal pot and then covered.
Risks of burns	There is low risk of burns from the terra cotta body.	The metal stove gets too hot and risks to burns are increased.	There is low risk of burns from the terra cotta body. The fire bricks construction effectively insulates the heat. The secondary air tubes effectively harvests the heat back to the gas column. Risks of burns in very much reduced. The stove gets less than " coffee hot" even after two hours of cooking.
Durability	One crack is a crack of the entire stove.	The metal stove will eventually succumb to chipping off and rust. Stainless can persist against chipping and rusts but the cost is multiplied.	The separate brick pieces isolate the breakage of one brick from the rest of the bricks. It also allows separate expansion and contraction of each brick pieces thus localizes the stress to the each piece of brick. It is much easier to replace a broken brick with another piece.

Handling and transport	transport without the metal canister. A metal canister or frame will reduce the risk.	Very light and easy to transport and handle.	With the stove in a metal canister, risks of breakage are reduced and handling is easier.
Replicability in an off grid community.	Highly replicable for communities with access to good quality clay and biomass fuel.	Replicability depends on the available supply of metal parts, tools and instruments.	Highly replicable for communities with access to good quality clay and biomass fuel.

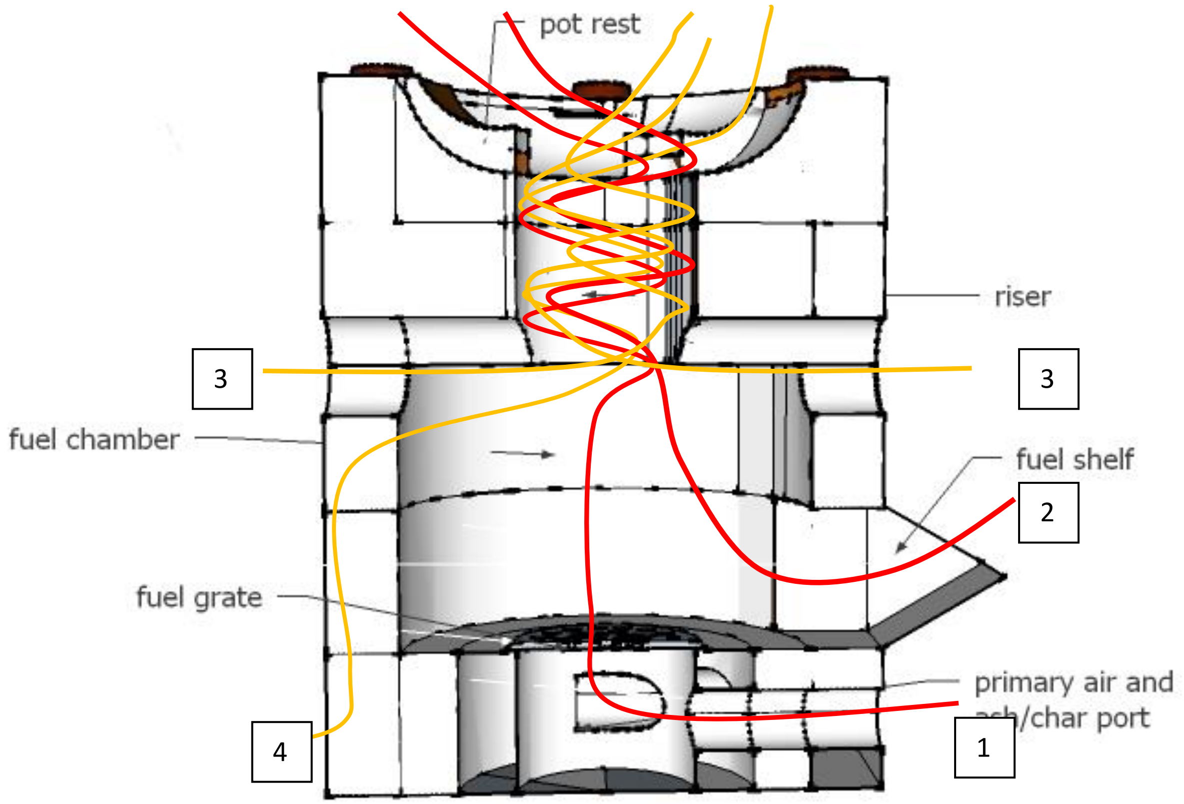
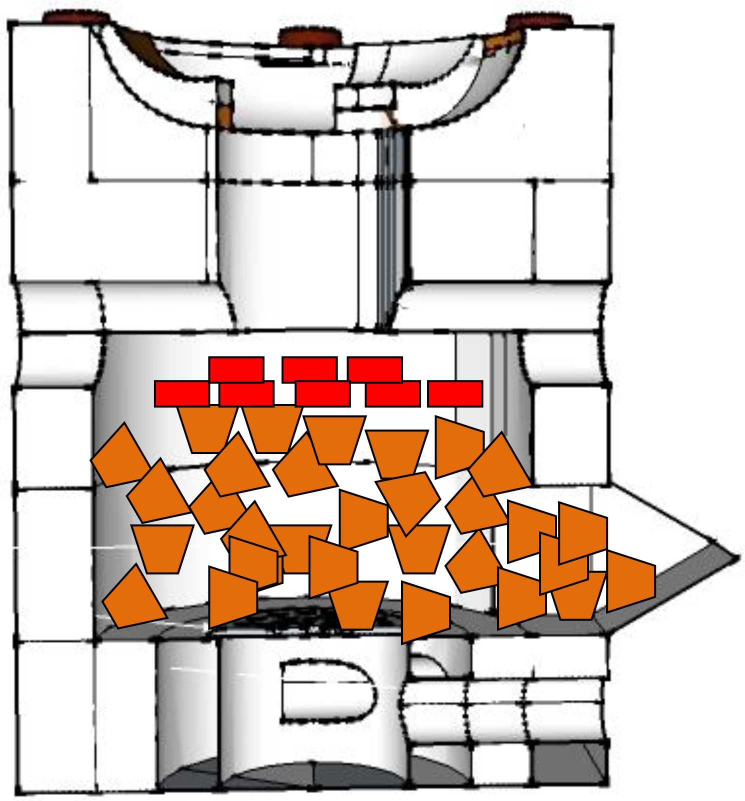
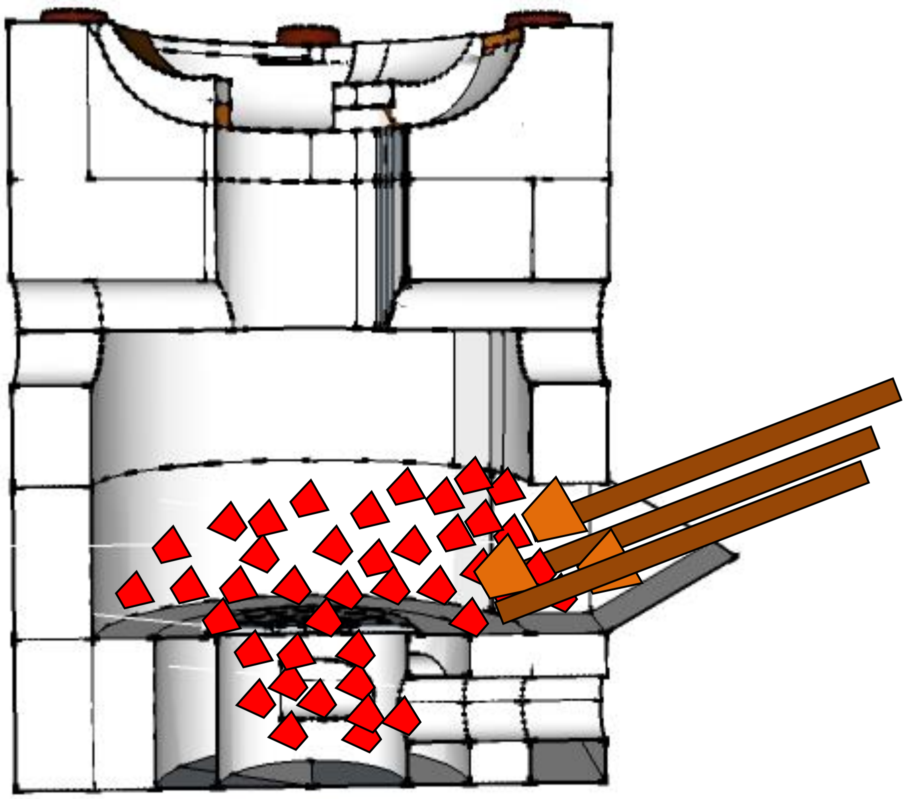


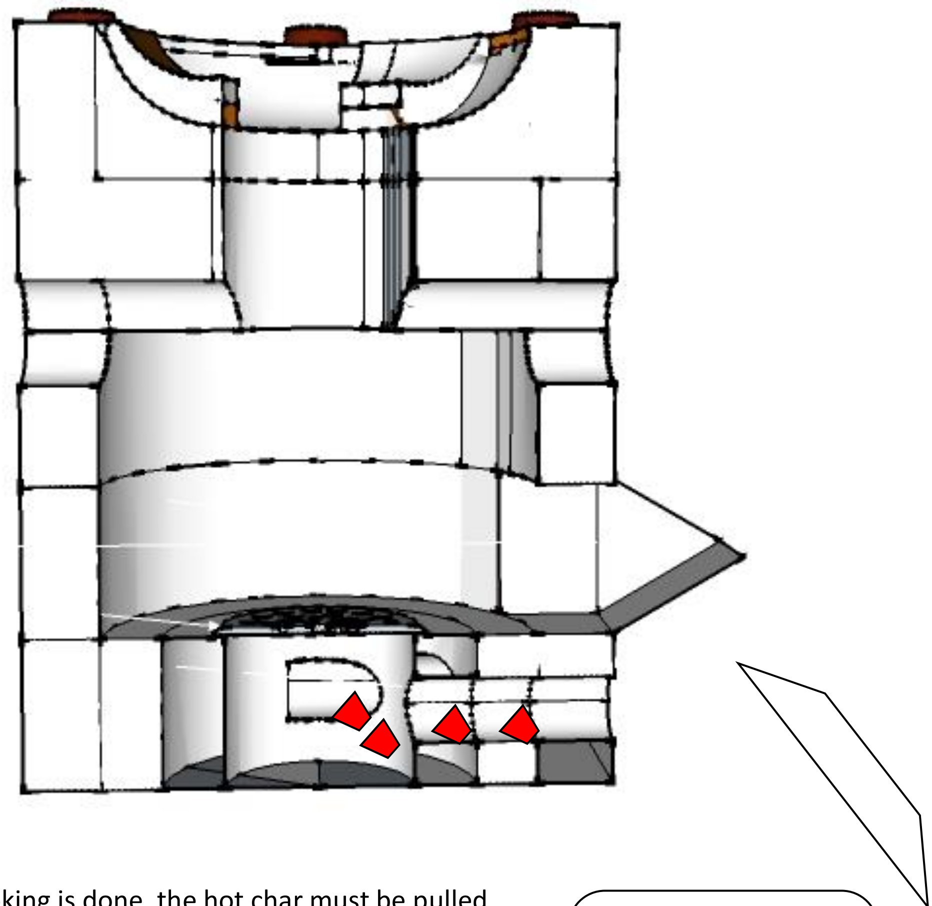
Figure 2. The flow primary and secondary air in the PPBStove. There are three air channels in the stove. First, (1) primary air passes through the primary air – ash/char port down at the base. Second, (2) primary air also come through the side fuel shelf. This is regulated by the small size of the opening as well as the fuel load itself. (3) During the hot start, secondary air is pulled in through the air port through the hole directly through the stove wall. And lastly and as soon as the stove gets heated up more secondary air shoots in through the stove wall (4). There are eight (8) holes of 3 and 4 each.



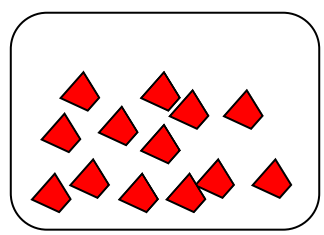
The PapaBrick Stove During the Cold Start Phase. The fuel  is poured from the top and fills the side fuel shelf to the brim. It is then lighted at the top and follows the TLUD mode.



The PapaBrick Stove During the Hot Start Phase. The first batch of fuel was consumed and leaves a very hot char bed. The size of the fuel has also reduced to as much as 1/3 and most fall off to the ash/char port. Fuel may then be reloaded on the side fuel port. Granular fuel may be pushed from the fuel shelf. Long wood sticks may be poked **deep** under the hot char bed. If this is not possible, long wood sticks must only be poked partially unto the fuel chamber. The side fuel port must always be filled to the brim to prevent too much primary air.



After cooking is done, the hot char must be pulled off to a metal pot and covered. This effectively stops the char from further combustion. We use the same metal cooking pot for harvesting the char.



Results of Tests. With limited tools and instruments for technical evaluation, herewith are the results of the tests.

1. One load can receive 1.25 kilograms of pilinut shells.

2. The shells are lighted at the top and follows the TLUD mode.

3. It gives 75 minutes of clean flame. This is more than enough to cook a set of meal for a family of six is which is about 50 minutes. It consists of one kilogram of rice, two set of viands and two liters of water.

4. It boils 4 liters of water in 14 minutes during the cold start and 9 minutes during the hot start.

5. Afterwhich, an average of 253 grams of char may be harvested or about 21% recovery. The hot char is dropped on a metal pot and covered until it has cooled down.

6. Wood sticks, coco palm fronds, coco shells, tablet briquettes is also possible to use but only after a hot char bed is created inside the fuel chamber, that is after the TLUD gasification cold start phase.

7. The stove weighs 28 kg when freshly assembled and the weights drops to about 22 kg. after several days of use and when the bricks have totally dried out.

8. Cost of production of the bricks is $8.35. Each stove has nine (9) pieces of bricks.

9. The selling price of each stove is $ 21 each. It includes the metal canister assembly and a 10mm stainless steel fuel grate.

10. During the past demonstration sessions held, the audience liked the stove because of the following reasons:

    a. With pili shells, they would have 45 minutes more of clean flame plus the char harvest compared to the wood charcoal.
    b. They also liked the assurance we give that we have more than enough pili shells in stock. Some even realized that they have their own stocks of pilinut shells.
    c. It gives a clean emissions profile. The pots do not gather sooth. We hold the demos at the street sides of the public market at dusk. We light up the stove lantern during every demonstration.

d. The stove does not heat up and saves the cook from heat fatigue during extended hours of cooking. We can touch the stove body for more than three minutes even after two hours of cooking.

e. The stove is made of fire bricks that do not break with intense heat compared to concrete. Their concrete charcoal stoves costs 1/4 as much but break in a few months. My terra cotta holey rokets lasts for more than 3 years.

f. The stove is amazingly lighter compared to the charcoal stoves of the same size. They are amazed about how a fire brick can actually float in water.

Way Forward. At this moment, (September 2015) we only fabricated twelve (12) units plus one unit of the bigger model and another ten sets of bricks ready to be assembled. It is because we are still under a trial period on how to best sell the stoves. With my team, we hold cooking demonstrations in the public market whenever possible. A shop selling wood charcoal and charcoal stoves was also commisioned to sell the PapaBrick Stove and pilinut fuel under consignment basis. More units were loaned to food business stalls for free use.

We now have a stock of clay good for another 50 stoves and four (4) tons of pilinut shells in stock. There is another six tons offered by another farmer. We will start producing the second batch after selling off all of the first batch and learning the best way to sell them.

We are currently exploring options of different marketing schemes on how to bring the price down and sell more.

ANNEXES: Selected Photos

From the works of Kirk Harris with his Wonderwerks Strata, the stove was fitted with a fin inside the riser (left). While it demonstrates some improvements, it still requires further tests. The off tangent jets of secondary air can already create the vortex even without the fins (left bottom photo).

The stove can be used with different kinds of fuel and still give clean emissions profile: (left) wood stick; (bottom left photo) coco shells (bottom right photo) tablet briquettes. This however requires that a hot char bed is already in place in the fire chamber. With this configuration, the stove provides intense fire power and continuous feeding.

The lantern I built (*inspired by the Stove Tech Lantern of Aprovecho*) on top of the PPBStove attests to its clean emissions profile.

The author (Jed) teaching community leaders on how to make the moulds for the brick pieces. The skills training (May 2015) was organized by the Plan International for the recovery of the communities affected by the Megastorm Haiyan in November 2013.

With the briquette King, Richard Stanley of Legacy Foundation during the Aprovecho 2014 Stove Camp.

The stove friends and classmates during the 2014 Aprovecho Stove Camp. Jed (red shirt) is at the front row with Dr. Paul Anderson to his right and a girl from Washington DC (Candice?).