Tegucigalpa Honduras
Market Stove 2004

This years project is to create a new stove for Honduras but I thought it might be fitting to pay a little tribute to the first Justa Stove ever made…..Five years and still kicking!!!!!!!!!!!

We built this stove in Jan 99' as a prototype for a Trees Water and People project. It was first built without a chimney, a thinner griddle and a provisional metal combustion chamber, all of which we switched out a few months later for the parts that still are working today. The metal griddle is starting to burn through (though there was a leak in the roof above that point which may have hastened the process as I saw other 5 year old griddles doing fine) and the old style ceramic combustion chambers had cracked and been repaired by them. All the other parts are still in good shape and Doña Miriam is still very proud of her stove.

Doña Miriam and her five year old Justa Stove

Five years ago Peter Scott, Larry Winiarski, and I (Mike Hatfield) got asked to come to Honduras and consult on the development of an improved cook stove for a 500 stove project being implemented by Trees, Water and People (TWP) and funded by Rotary Club International. The community we were to work in already had a lot of association with improved cook stoves and were set on wanting a stove with a griddle. For that reason we created the Justa griddle stove which has been an incredible success in acceptance as well as fuel savings over the last five years all through Central America. But the stove costs somewhere around $40 in materials and between $60 to $80 per stove with labor and project overhead included which puts it a bit out of the price range for most people in Central America. The majority of the some 10,000 stoves built have been built with the help of aid agencies such as Rotary Club or Helps International. Also each stove takes about a half day to build The Justa griddle stove is great for tortillas or for multiple pot cooking but we have always known that for single pot cooking we cook make a much more efficient stove. From the beginning of our work in Honduras five years ago we dreamed of coming back and making a stove which would be even more efficient, affordable to most every person and could be made in large numbers, hopefully by a local builder who could have a successful business without the need for external aid. We are now starting a project to do just that. This winter in Honduras , with the help of TWP, Larry, Damon Oagle and I started the creation of an inexpensive but efficient stove which can be produced in large numbers and cost as little as $5. Here is a overview of how the project has started.

In the end I believe that the production of a marketable stove for Honduras will come in three intermingled stages, always works in progress, but chronologically somewhat distinct. 1-- Determining the most viable form of the marketable stove. 2-- Setting up the production of the stove and 3-- Marketing the stove. For the most part we have been grappling with the first part (probably the easiest and most fun for us stove geeks) which can be divided into eight main points at this time.

1— **What Material do we use for the stove body**? Our choices are either find a way to produce a lightweight insulative ceramic (IC) or go with the baldosa in a bucket surrounded by ash. In Honduras our choice for material to make IC is organic matter and clay. We tried rice husks and coffee husks but found sifted sawdust to work best. Damon and I spent most of our time trying to find a good local recipe for the first choice. This is our ideal choice but it needs to be recognized that most likely any light weight brick is not going to be as strong as the denser baldosa so actual in field longevity will be the deciding factor. We tried some thirty different recipes using mainly two different clays and varying amounts of sawdust and water. We are working in a brickyard near Tegucigalpa which has a large kiln that gets fired for a minimum of 30 hours and reaches 1050º C. Unfortunately our time was limited and we could not get our test bricks into the kiln of Don Pedro. We had to settle for renting a smaller kiln and firing the bricks for 9 hours. We pulled them out the morning of 27-3-04 and they tended to be on the light side and under fired. We got to the lower end of our temperature needs (960º C) but with IC it is really important to have the longer burns to get the heat saturated throughout the brick. The smaller kiln also may not have reached this temperature throughout the entire kiln. Because of the shorter burn and possible lower temps the bricks shrank less (leaving them less dense) and not becoming quite as hard as we expected or would have liked. Before we left we made more bricks that should come out a bit stronger (and heavier) but we feel it is the best compromise for the sake of longevity. They were to be fired after Damon and I left in Don Pedro's kiln and Larry and Agusto will get them in the field for us. We feel we have a good recipe but as I said lifespan in field will be interesting. If you are interested in the numbers the bricks we made ranged in density from as low as .4 g/cc to 1.1 g/cc (baldosas here are about 1.4). We have stated before that .8 would be a nice number for our insulative bricks but we have decided to try for .9 to give them a better chance in the field. If they survive with flying colors we can lighten up later.

A variety of test mixes of insulative ceramic

Damon tending the fire

Opening up the kiln

The center of some of the bricks did not fire high enough

2-- Find a durable but cheap container for the stove. This is especially important for the insulative ceramic (IC) brick but a container will be needed for the baldosa as well. The options we looked into were tin bucket ($2), angle iron or platina at strategic points around the stove which double as pot supports ($1-2), or a ferro-cement mix with pot supports embedded in it ($1.50) We also will look into making the body of the stove with a thin layer of pure clay as a built in and very cheap container. We know this will work from bricks we have made at Aprovecho but the feasibility of it will be seen when we get into actual production of the stove.

Good ol' baldosa in a bucket. Bucket might prove strong enough to double as pot support.

A $1 combustion chamber and $.75 pot support…price is right but will it last?

Cement stucco stove with metal pot supports embedded in cement

3) **Making durable pot supports**. In test bricks at Aprovecho we have been making our pot supports built into the ceramic of the stove and made of the same material. But we have decided here that for longevity it is best if they are made of metal and go all the way to the ground to avoid passing the weight of the stove onto the IC brick. Metal is rather cheap, at least right now, and a metal form for the stove which serves as the pot support will cost as little as $.75 in material plus the labor costs (which will vary depending upon whether we are producing them in house or not).

4) **Durability of combustion chamber against abrasion of sticks**. If we go with the baldosa combustion chamber this will not be an issue but if we use IC brick then it will probably be the weakest link in the stove. I put together a six brick stove with baldosa for an entrance and the back of the combustion chamber protected with the 1/2 inch thick roofing tiles that are ubiquitous here. This should be a simple and inexpensive solution and we can do the same with smaller pieces of the baldosa which we know can withstand the heat of fire and impact of sticks. As with a the outside of the stove we will look into making the inside layer of the IC bricks out of pure clay.

Thin roofing tiles fit nicely in the back of the combustion chamber to protect from stick abrasion

Upside down view of six brick stove shows how roofing tiles and baldosa can be used to protect from stick abrasion

5) **Easily reproducible stove parts**. We have been making our test bricks at the brickyard of Don Pedro and he is very interested in the possibility of setting up at least the mass production of bricks there if not the complete production of the stove. He is already making the baldosas and is very amiable. His kiln also is larger then most and therefore fires for a longer time then most here which is in our favor. Besides that he makes his bricks in large numbers (up to 10,000 a day!) using a motorized mixer and extruder. Larry is working with him to adapt his extruder to extrude trapezoidal six bricks in mass numbers. Even if the extruder does not work then just using the mixer and molding the bricks by hand will speed up and cheapen down the process. If in the end we decide to manufacture the bricks somewhere else it should not be hard to set up a similar mixer for the bricks. Besides the trapezoidal bricks we have been working with a fiberglass mold that Damon made and brought down. It works well and would be easy to set up in a more mechanized manner to mass produce monolithic stoves. It also produces one beautiful stove as far as aesthetics go. As a third option we have made a version of the baldosa elbow but with the lightweight material and two inches thick. It is another option but not as sexy as either the six brick stove or the monolithic.

Combination mixer/extruder at the brickyard of Don Pedro is a dream come true for mass production of insulative bricks

6) **Shirt for the comal and pot**. We have not spent much time of this trip on an adjustable pot shirt but have a few designs up our sleeves which will work fine later. The biggest problem with a skirt for the simple rocket is that it needs a seal at the bottom for it to work. For the cheapest stove possible this may not be easy but Larry started us out thinking on a design and we have been working now on a intermediately priced stove which has a comal skirt which will double as a bottom seal for a pot skirt. Basically it is a metal or ceramic base which follows the contour of the comal as it goes away from the exit of the elbow to give the best heat transfer to the comal. We are looking at it extending out about 10 cm beyond the stove body to remain stable and work well with the larger pots and comals. It looks like it will cost somewhere around $3 in material costs (plus another $1 or so for an adjustable pot skirt) plus the cost of labor. Once again a big work in progress.

Comal shirt which built in pot supports and notches for adjustable skirt

Testing six brick stove with comal and comal skirt

7) **Using a grate and/or shelf in stove**. Damon and Dean did some initial testing of the rocket stove with and without a shelf and/or grate and found in initial tests that there is a significant difference in efficiencies in the options. I took these numbers and did some further calculations and came to the conclusion that if 30% of the people use their shelf then the savings in fuel will be greater if a shelf is built in. I will explain this below but the basic idea is that the shelf costs a small sum which equates to a free stove every 24 or so stoves if it is not included. This means one less person consuming the amount of wood in a traditional stove and at 30% shelf use the fuel savings for the two options are about the same. A grate is even more efficient and therefore even more desirable though there is a question in longevity with a grate for the coals. The point is that it is worth putting effort into getting people to use a shelf. Besides the fuel savings it also reduces the production of charcoal which for our small combustion chambers is rather important. We are looking into ways of making the shelf or grate less tossable in the stove and reinforcing to Ahdesa that they should work to get people using the shelf.

A couple of metal and ceramic shelf/grates

Shelf or no Shelf……..

PHU tests done by Dean and Damon found an average efficiency differences as follows for three tests:

	Efficiency	For comparison
No shelf —	11.6%	100%
With shelf —	13.3%	113.8%
With grate	15.85%	135.7%

Taking the most conservative reports as true that the Justa stove saves 50% of fuel consumption then we can look at the choice of using a shelf of not in the following manner.

Lets say a Justa without a shelf costs $48 and to add a shelf it would cost and extra $2. This means that with the same amount of funds ($1,200) you can either build 24 stoves with a shelf or 25 without. Note that if you choose to build 24 stoves with a shelf that will leave one family with a traditional stove.

If, for the sake of simpler math, we say that a Justa without a shelf uses 23 convenient wood units (CWU) per day then a Justa with a shelf should use 20 CWU (23/1.138) and a traditional stove should use 46 CWU (23/.5)

Here is the theoretical wood consumption per $1,200 spent for building w/o a shelf and for building with a shelf at 100% and 30% shelf use.

Stove type	W/O	W-100% use	W-30% use
With shelf	0 x 20 = 0 CWU	24 x 20 = 480 CWU	7 x 20 = 140 CWU
W/O shelf	25 x 23 = 575 CWU	0 x 23 = 0 CWU	17 x 23 = 391 CWU
Traditional	0 x 46 = 0 CWU	1 x 46 = 46 CWU	1 x 46 = 46 CWU
Total Consumption	575 CWU	526 CWU	577 CWU

We see then that if the above numbers for efficiencies and stove costs are assumed to be true then if more than 30% of the people use the shelves in their stoves then it is worth the investment to build them in the stove. There are other factors to take into account which make the choice more complicated such as the increased usability of the stove with a shelf because of reduced charcoal and the fact that there are health concerns to be considered in leaving someone with a traditional stove .

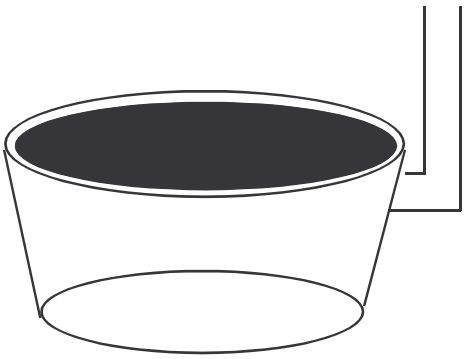
8) **Super Rocket with Chimney**. Finally Larry has been working on getting a design for the super Rocket with Chimney and all the works. This is also much a work in progress but the basic idea will be that the simpler chimneyless rocket stove can be placed in a larger container such as a half barrel or larger sheet metal tin with a chimney built in.

Integrated parts— There are basically 4 separated pieces that will make up the Super Rocket. Our idea is that each part, starting with the central combustion chamber/stand alone stove, can be purchased separately as money becomes available. First someone can buy a simple rocket with shelf/pot support/ durable container/protection from sticks for somewhere between $5-$10. Then they can purchase a skirt for the comal for a few more dollars and next an adjustable skirt for the pot for a few dollars more. Finally, for an additional cost, the container for the supper rocket with chimney and built in comal can be bought to complete the system. Final prices will vary quite a bit depending on how we produce the stove but hopefully we will be looking at less than $20 for the entire set.

Prototype (in a big way) of the basic rocket stove. $4 in materials

Add a conical skirt for the comal

Imagine this flimsy piece of metal as an adjustable pot skirt to increase the efficiencies of the stove



Finally, put the first two pieces plus a comal in the Super Rocket container to make a chimney stove

Well that is two weeks of work (to top off many years of work prior of course) and it will be fun to see the project progress. We just got a grant from the EPA to make this stove a reality so as far a Honduras goes we only have some 2 million stoves more to build. Wish us luck.