Improved cook stove in operation six months after construction

Improved Cook-stoves

Introduction

The majority of people in developing countries must rely on wood for cooking and heating. In some ways, it is a much better method than natural gas, propane, heating oil and coal produced electricity used in developed countries. Wood is a much more renewable resource than the other energy sources listed which will not be replaced for millions of years. The downsides of using wood include pollution – both outside and inside the kitchen, the time and energy needed to collect the wood, risks for burns and deforestation.

Many people use very simple structures for cooking that are little better than an open fire. Three or four pillars made from local mud or similar materials support a cooking pot. Although simple, these traditional structures are not efficient and allow the cook and others in the vicinity to be exposed to significant amounts of smoke. For anyone who has been inside a building with an open fire, they know the stinging eyes, nasal congestion and choking cough. Discussed below is a simple stove design built in Honduras. This design can significantly reduce smoke exposure and can reduce wood use by 50% or more. Although not discussed in detail, other stove designs will be mentioned that may be more appropriate in other situations.

Basics of Stoves

A fire needs an initial heat source, fuel and oxygen. By controlling the amount of fuel and oxygen, the temperature and rate of fuel consumption can be controlled to an extent. Controlling the amount of oxygen reaching the fire is achieved by building a container that is air-tight except for one opening where the user can control the amount of air. Ideally, a chimney will also be used to increase air flow (draft) and remove smoke from the area immediately surrounding the stove. One of the more challenging design considerations is melding the cooking styles of the

target population with the need to close off the stove. Hondurans do much of their cooking on a large flat metal plate where they make tortillas. This makes closing the top of the stove off easy – the large flat metal plate does that. Other groups may only cook in pots. Ideally the flames will heat the pot directly. Given there may be multiple pots of varying sizes, the challenge is finding a method to create an air-tight seal for each pot of varying sizes.

Using as many locally available materials as possible in stove construction offers a number of benefits. Most people who use wood for cooking do not have much money. Using locally available materials reduces the amount of money needed. Local people are generally familiar with how to work with local materials. Many times the local people will know much more about working with the local materials than does the "expert" stove builder from outside the community. Ask local people how they build traditional stoves, paying particular attention to the collection and preparation of local materials. In many instances, local materials may work better than higher cost materials. For the un-initiated, they may believe building with cement or concrete will build a longer lasting stove than one built from locally harvested mud. This is not true. The mud is a superior material for stove construction and will withstand the high heat of stoves better than a cement-based structure would. Another example involves the chimney. Using a metal chimney eases construction but the metal does not handle high heats as well as local muds. When the mud does crack or wear down, repair is a simple matter. Purchasing a new metal chimney may be out of the reach of the local people without the help of an aid agency.

Benefits of Honduran Stove

The Hondurans in central Intibuca, Honduras use a traditional stove that consists of a flat metal plate supported on a two or three sided wall made of local mud. Although the traditional stove is easy to build and low cost, this stove design has a number of draw backs. As mentioned previously, the traditional stove creates significant indoor air pollution that increases respiratory and visual problems. Women and children spend significant time and energy collecting firewood. By reducing the time a woman spends collecting firewood, she has more time to spend caring for children or possibly even doing another activity that can bring more resources into the home. In Honduras, with that free time, a woman might be able to collect fruits to sell in the market. The more calories people burn collecting wood, the worse their nutrition. Reducing physical labor by reducing how much wood needs to be collected actually results in improved nutrition. It is almost as good as providing more food when people are hungry. Excess wood consumption leads to deforestation and the degradation of land. A final danger of the traditional stove is an increased risk of burns – particularly for children.

Benefits of Improved cook stove

- Improved air quality in the home
- Reduced pollution for the environment
- Reduced time spent collecting firewood
- Reduced calories expended collecting firewood and improved nutrition
- Reduced consumption of firewood
- Reduced deforestation
- Improved fertility of the land
- Reduced risk for burns

Women in the project area estimate wood use has been reduced by between 40% and 80% with the new stove design compared to the traditional stove. Kitchens that were previously black inside from the soot now have white-washed walls. Not only does the kitchen look cleaner, but the bright walls allow people to better see what they are doing. Women and children can remain in the kitchen without coughing or having eyes burning. The burn risk has also gone down with most of the fire not accessible to small hands.

Traditional stove – note black walls

Traditional stove – note open front design

Building Plans for Honduran Stove

Form construction

The form for this stove is basically 2, four sided wood boxes, one inside the other. The mud is placed in-between these boxes. Both boxes must not be permanently constructed. They are removed once the mud has dried enough to maintain its shape. One form can be used again and again to build many stoves. Construct the forms out of 1x12 boards or plywood.

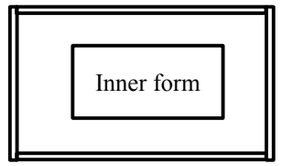
Parts list

Purchased materials

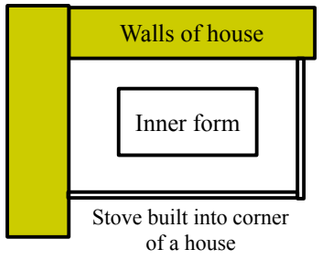
- Plancha – 22 inches by 30 inches (actual dimensions not important, but larger size is more desirable because an entire meal can be cooked at one time).
- Chimney pipe and hat – 2 @ 3 ft each. More than 2 may be needed depending on height of roof and the need for improved draft. Heavier gauge steel will last longer
- Barb wire – about 20 ft – used as a reinforcing material inside the mud
- Forms - 1" x 12" boards to create forms – dimensions vary based on the size of the stove desired. The form is re-used and should only need to be made once.
- Nails or screws – 4-12 needed for form construction
- Ree-bar – only needed if using large Plancha (metal plate) 2 @ 6-8 inches wider than the Plancha width.
- Cement – small amount used to seal the hole in the roof where the chimney penetrates
- Roofing tiles – 3, may be available locally. Could also skip this part and use mud instead (see below).

Locally available materials

- Local mud – ask local people what they use to build stoves
- 1 metal can – locally available oil can is used
- Adobe block – 3, used to make the mouth of the stove



Free-standing stove

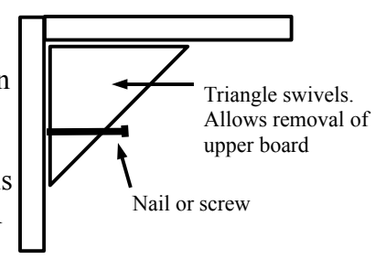


Stove built into corner of a house

The actual dimensions of the form are dictated by the size of the Plancha. There are two sizes of Plancha available locally in the San Jose area – small and large. The women prefer the larger Plancha because much more food can be cooked at one time. The outer walls of the inner box should be at least 3-4 inches smaller in length and width than the size of the Plancha. This allows the Plancha to rest on the mud walls all the way around. See the diagram below for details. Once the dimensions for the inner form are determined, build the outer form large enough to create mud walls that are at least 8 inches thick. Consider making the end where the chimney will go at least 3-4 inches thicker. This means the inner form will be offset some so that the end where the chimney goes will be thicker than the end where the opening to feed wood goes. When the stove is built into the corner of a house, the two walls of the house can be used as two of the outer form walls (see diagram below).

The four boards making up the inner form cannot be attached with hardware such as nails or screws. This form needs to be removed once the mud walls have hardened. Consider using 1-2 small triangles of wood that can swivel out of the way at each corner (see diagram to the right). This allows easy removal of the inner form.

The outer form can be partly nailed or screwed together. Do not attach the boards permanently. Each board will need to be removed separately once the mud has dried. When using the walls of a house as two sides of the outer form, consider just using weights placed against the forms to hold them in place.



Make sure both forms are level and square. This will ensure the stove is also level and square. A

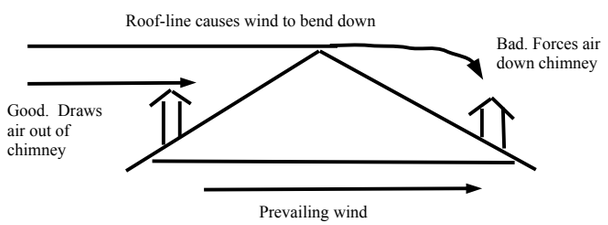
stove that is not level will make cooking more difficult, particularly when a pot is near full and the food keeps falling out of the downhill side. A simple method to ensure the forms are square is to measure the diagonal across corners. A box with all four corners being 90 degrees will have the same diagonal length. If a commercial level is not available, use a pot filled with water placed on top of a flat board placed across the form. This rough level will allow enough accuracy to ensure adequate performance while cooking.

Foundation for the Stove

The Honduran women in the project site prefer having the top of the stove at about waist height. This improves the ergonomic working conditions and reduces back strain. Elevating the stove reduces the burn risk for children. The elevated stove also reduces the amount of chimney pipe needed. Given the cost of chimney pipe, reducing this expense is very desirable.

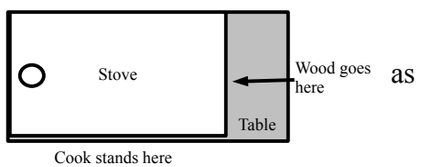
Before building the table, talk with the main user of the stove and ask them where they want the stove. In San Jose, the husband often takes on the building of the stove while the wife is the one who uses the stove. In one instance, the stove was built inside the house where the husband thought it should go. After construction, she would have preferred if the stove had been built outside. She often finds herself cooking at dawn and dusk when there is limited natural light. Having the stove outside under a roof overhang allows her to better see the food.

Another factor to consider when siting the stove is the location of the chimney. It will need to penetrate the roof. Place the stove so that the chimney location will not require relocating a structural member of the roof. Prevailing winds in relation to the roof line and the location of the chimney also matters. Ideally the chimney will extend well above the highest point of the roof. Due to the expense of chimney pipe, this is often not possible. Many times the chimney pipe barely penetrates the roof. In this situation, the chimney should be upwind from any obstruction such as the roof line. This improve the draw of the chimney. A straight chimney pipe functions much better than placing bends in the pipe. Avoid bends whenever possible.




Mesa built of cement drying

A table or mesa is constructed out of local materials. A common local method is to use locally made adobe blocks. Local mud is used as mortar to hold the blocks together. The blocks are stacked until a surface high enough and large enough in length and width is built. Knowing the dimensions of the outer form is essential to knowing the size of the table. If a woman wants the Plancha to be at 26 inches high and the form is 12 inches high, the table height should be 26” - 12” = 14”. If the outer form dimensions are 36 inches by 48 inches, the table width and length must be at least that large with a few inches extra. Most women cook from the side of the stove with the long dimension. Therefore, do not make the table much larger than the width of the stove on this side. Doing otherwise will force the woman to bend often to reach the cooking surface. This increases back strain and the risk for burns. The table is often made at least 6-12 inches larger at the end where wood is fed into the stove. This extra table size at the end helps support long pieces of wood that stick out of the stove. Locally available wood is often 2-3 feet in length. Much of the wood is actually outside the stove and slowly advanced into the stove as the wood inside the stove is consumed.



A number of adaptations have occurred with the construction of the table. Many people like to have a space in the table that is immediately below the stove where pots can be kept warm or clothes can be dried. The most important thing to remember when creating these spaces is that the finished stove will weight many hundred pounds. Any gap left in the table for this shelf must have a "roof" structure of the gap strong enough to support the weight of the stove. Given the proximity of the gap to the fire, using combustible materials such as wood for the "roof" can lead to interesting problems. I have seen wood structures for the table catch fire and burn through. This often necessitates rebuilding the table and stove.

Some people desire storage space under the stove. They have built a sturdy table out of locally available wood and mud to support the stove. Make sure that at least 4-6 inches of mud protects the wood members from the fire. The wood members must be strong enough to support the weight of the stove.

Mud and Other Stove Wall Materials

Talk with local people about the best material to use for stove building. They have most likely been building traditional stoves out of locally available materials for hundreds of years and know what works best. Explore with them the various options available. There may be multiple local materials available, all with different characteristics, strengths and weaknesses. They are truly the experts in this area and will know where to get the needed materials. In many instances, more than one type of mud may be mixed together and other additives such as termite mound mud or animal dung will go into the mix. One interesting addition in the San Jose area involved soaking in water the bark of a certain type of tree. This water was then used to mix the mud. The tree bark had a very sticky sap which made the mud stick together better and reduced the risk of cracking later.

Part of the reason a form is needed is because the mud available locally does not hold its shape well until it dries. If the mud available locally works more like modeling clay, then a form may not be needed. Another form-less option might involve building the stove walls with locally made mud blocks held together with a mortal of mud. Again, talk with the local people to determine the best materials and methods for stove construction.

Do not be tempted to use concrete or cement block for stove construction. The cement does not stand up well to the high temperatures inside the firebox and will rapidly start to crumble. It is acceptable to use cement on structures further away from the firebox. For example, the sides of the stove and table walls could be plastered with cement to improve the look and reduce the amount of dirt coming off the stove walls.

Building the Stove

Once the table and forms are made and the selected mud is on site, it is time to build the stove. As with most projects, careful preparation is the most important part and will ensure a good end result. Before making the mud, ensure all the materials needed are available and that the form is level and square.

Start by placing about one inch of wet mud in the bottom of the space between the inner and outer forms. Place the two end bricks that form the sides of the wood opening. Consider placing a wood spacer between these two bricks so that the bricks are not knocked over as more mud is placed around the bricks. Then place the top brick onto the two side bricks. Carefully pack mud around the bricks with mud to secure them in place.

One modification we have found helpful is to place barb wire inside the mud. This works like ree-bar in concrete to reduce the mud from cracking. We place about 3 levels of barb wire inside the mud. Every 2-3 inches of mud we place a single layer of barb wire horizontally in the mud.

The metal can that will form the base of the chimney needs to have one end removed and a hole cut in the side. This hole will face the inner form and will allow smoke to pass from the firebox into the chimney. Once the can is prepared, it goes in between the two forms at the end opposite the firewood opening. Place the can on about 2-3 inches of mud until the top of the can is level with the top of the forms.. Place a piece of cardboard over the side opening of the can. The hole in the can covered by cardboard is placed very close to the inner form. Once the forms are removed, the cardboard allows easy access from the firebox into the

can.

Once the wood opening and metal can are in place, it is time to fill the space between the two forms with mud. Remember to place barb wire inside the layers of mud as mentioned above. Smooth off the mud to be level with the tops of the forms.

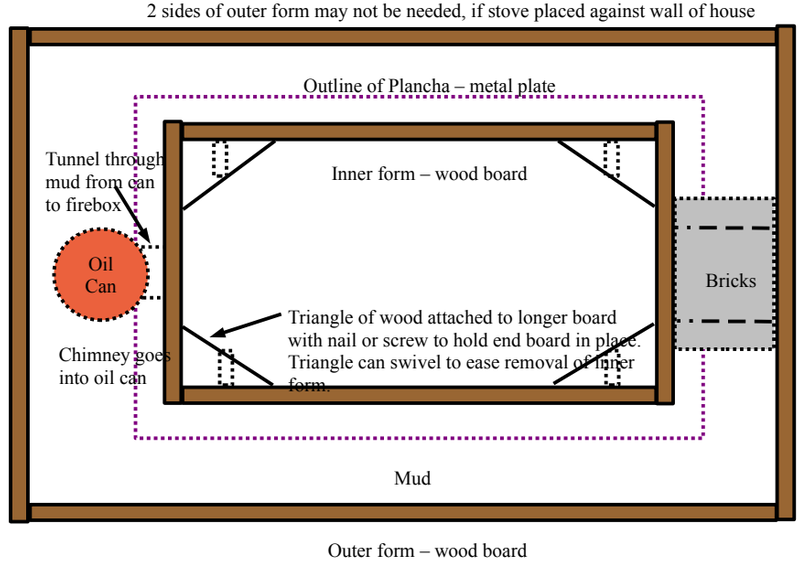
The next step is to install the chimney. There are many options possible. The metal chimney pipe could be attached directly to the top of the metal can and sealed with mud. Given the metal chimney will deteriorate over time due to the high temperatures experienced so close to the fire box, we like another method. Place three clay roofing tiles on end in a circular fashion over the metal can. A rough pipe is formed by doing this. We hold the roofing tiles together with a few wraps of barb wire, although any flexible wire can serve this purpose. Then mud is packed around the roofing tiles to a thickness of about 2-3 inches. At the top of the roofing tiles the metal chimney is fitted and sealed in place with mud.

We have found the best method to seal the roof penetration of the chimney pipe is to place a cement-based mortar (1 part cement, 3 parts clean sand and just enough water to make mixture workable) around the chimney pipe on top of the roof. The top of the chimney pipe should be sealed with a pipe cap. The larger the cap, the less likely a heavy rain will allow water down the pipe and into the firebox.

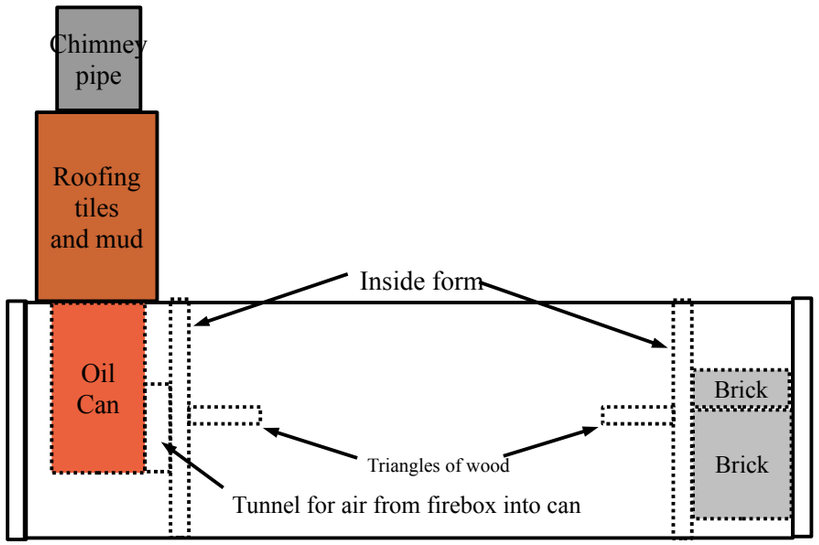
In about 1-3 days, after the mud has dried enough to be firm but not solid, the forms are carefully removed. Cut a hole through the mud from the firebox into metal can. Ensure the wood opening in open and clean. When using a large Plancha, consider placing 2-3 pieces of ½ inch (#4) ree-bar across the firebox to support the Plancha. Some large Planchas have warped when heavy pots were placed on very hot Planchas. Each piece of ree-bar should be long enough to be supported by at least 3-4 inches of the mud walls on each end. Cut a groove into the mud so that the top of the ree-bar will be flush with the top of the mud. The Plancha is then centered over the opening of the firebox. About 2 inches thick of mud is placed around the edges of the Plancha to seal it in place.

After a few more days of drying, the stove is ready to be used. Many people like to plaster the outside of the stove with a lime and water mixture or a light cement plaster. Another handy addition to the stove is to build a small hoe to remove the ashes from the stove. The hoe is made of wood or other locally available material. It has a handle long enough to reach all the way to the back of the stove and the blade part must be small enough to fit through the opening used to feed wood into the combustion chamber. When the stove has significant ash, the fire is allowed to die out and the ash is removed with the assistance of the hoe through the fire entry opening.

Plan for San Jose Stove – Top View



Plan for San Jose Stove – Side View



Entry for wood and air

Inner form in place and positioning outer form

Making sure form level

Placing bricks in place for air-wood entry

Wood spacer holding bricks in place

Placing top brick in place

Placing mud around bricks to seal in place

Placing mud in form

Placing barb wire in form

Placing chimney tiles on top of metal can and wrapping barb wire around tiles to hold in place

Placing mud around chimney tiles

Finished stove drying after removal of forms and placement of Plancha

Methods of Introducing and Supporting Improved Stoves

Every community and culture will require stove introduction and support methods tailored for that group. Methods that work great in one community may fail miserably in a different community. Talk with local people to get a better understanding of how new concepts and projects in the past have been introduced, disseminated and maintained. Talk to the people that will be using the stove as well as those who are building the stove if they are different. Focus groups with a cross section of the population may provide valuable information. After a method is decided upon, start small and form 1-2 limited tests. Learn from those experiences and adapt the method for improved outcomes. A few basic methods are introduced here to give suggestions.

One almost universal concept is to not give stoves away for free. There can be rare exceptions for the truly destitute, but outcomes long term are almost always better when the beneficiaries have at least time and materials invested in the project. It is human nature to not respect and care for something you got for free as much as something you really worked hard to obtain. When the end users are actively involved with construction, they are better able to repair the stove when needed and are empowered to experiment with modification and improvements.

Requiring payment for stoves does not mean the end user will pay for the entire project or that the supporting agency will make a profit off the poor. In many cases, the beneficiary will pay a modest 10%-20% of the cost. The dollar amount is based on the average family income so that everyone or almost everyone in the area can afford the project. For example, local people paid about $5 towards a total stove price of $30 for the San Jose project. In severe poverty cases, the fee may be waived, but this should be a rare exception.

All materials that can be gathered locally must be provided by the end user. They should also provide free labor and be actively involved with the construction process.

The first method tried was to have a Peace Corps volunteer assist with the distribution and building of every stove. Although successful, this process was too slow for most people in the area. They wanted things to move faster. We next tried a see one – do one – teach one approach with just oversight by the volunteer. Given the very reserved nature of the people and the difficulty scheduling three families to be available at the same time, this method did not accelerate deployment as rapidly as hoped.

The method being used presently involves a community champion/teacher and classes held in each village. One house is chosen in the project village. Interested community members are invited to attend the workshop where a stove will be built. Students actively participate in the construction of the project stove. At the end of completion of the project stove, interested recipients are reminded of the inclusion criteria and can purchase the reduced price stove parts. During a two month period of time 50 new stoves were built. This was run by an unpaid community volunteer working when he had free time to hold classes.

A number of criteria were used in the San Jose area for inclusion in the stove project. Given the subsidized cost for stove parts, we did not want people getting the low cost parts then turning around and selling the parts for a profit in the local market. Another issue that arose was that wealthier families wanted enough stove parts for two stoves in one house. It was decided that until everyone in the area that wanted a stove had one, no family could have more than one improved stove built with the low cost parts. Another issue was people were trying to get stove parts for future houses.

<u>Criteria for Receiving Subsidized Stove Parts</u>

- One stove per household
- Participant must attend workshop
- Stove must be built within one month of receiving parts
- Stove part recipient must be living in the house now
- Participant pays $5 for parts
- Participant provides all locally available materials
- Participant must build the table for the stove
- Participant must be actively involved in stove construction
- Participant must assist with another stove construction

Stove building workshop

Stove parts being distributed and people carrying home

Additional Stove Designs

There are many improved stove designs available. Interested readers should get one of the expanded texts referenced below for more ideas. The first step before considering a novel stove design for a community is to study the cooking methods used locally. For example, many stove designs used in Africa have two or three small round holes where small pots are placed. There is no large metal cooking surface for making tortillas. This three hole stove would not work in Central America where tortillas are served at every meal. Conversely, having a large metal cooking surface would not meet an African's cooking needs and would significantly increase the cost of the stove.

Learn how many different types of pots are used to prepare each meal. Note the type, size and shape of each cooking container. Determine which types of foods are prepared on the stove. Both the cooking vessel and the types of foods prepared will come into play when introducing a new stove design. Note the different temperatures needed to prepare certain dishes or parts of the meal. A hot

fire may be needed to bring water to boil but then the food may need to simmer at a low temperature. Most traditional cooks vary the heat of the fire effortlessly by moving the fuel around. This level of control needs to be available in the new stove if people are performing these tasks presently. Any new stove that cannot meet the cooking needs of the family will not be maintained or used over time.

In some areas, more than one stove design may be used. In San Jose, a stove with a large flat metal plate is essential. However, having another stove that can support a huge round-bottomed cast iron pot used for cooking corn and tamales is very desirable. In San Jose, two different stoves, one to meet each cooking task, would be ideal. With advanced metal working skills, it may even be possible to create one stove that meets both needs. However, the cost may be prohibitive compared to building two stoves using mainly locally available materials.

Some simple principles must be followed for improved stove designs as were mentioned at the beginning of the chapter. The most important consideration when designing a new stove is to control the flow of air into the combustion chamber. Ideally, the combustion chamber will be sealed air tight at every location except the inflow opening (usually where the wood is inserted) and the chimney. Controlling the amount of air reaching the fuel allows the user to easily adjust the heat of the fire. Using air to control the heat of the fire may be a new concept for users of the stove to master. In many open fires, the heat of the fire is controlled by altering the amount of fuel and the spacing between fuel pieces. With the new stove, this may be done by limiting the amount of air reaching the fire. The San Jose stove design allows limiting air flow to the fire to control temperatures, However, the San Jose users still control the heat of the fire by moving the wood around. In many instances, long this pieces of wood are still used for cooking and much of the wood sticks out of the end of the stove and therefore can be moved around easily.

For users that must have two or more pots being heated at one time and each pot must be at a different temperature, the stove design may need to have multiple heating points that are variable distances from the actual fire. The pot that needs the most heat will be located on the hole directly above the fire. A pot that needs to simmer may be on a hole further away from the fire.

The Lorna stove of Guatemala is the best known example of a multi-holed stove. See the drawing below for a visual explanation. Each pot hole can have a pot on it or a metal plate to cover the hole. It is important to cover the un-used holes to reduce smoke escaping from the stove and improve draft. In general, the diameter of the holes are built to accept a specific pot. This fact is the reason the size and types of pots used must be known.

It is possible to create a similar stove using a large metal plate. Significant woodworking skills will be needed though. This can significantly increase the cost to build the stove. The large metal plate (Plancha) have the round holes for the pots cut into it. A lip on the underside of the plate must be welded to the bottom of the Plancha. This allows the circles of metal to be placed into the holes to fill them when a pot is not filing the holes. It would then be possible to make concentric circles to accommodate multiple sizes of pots. This does not tie the use of the stove to specific sizes of pots.

Another common stove design that is used in Africa is a single pot stove that is small and portable. It is made from a metal can/pipe. Ideally charcoal is used and almost critical to proper operation of the stove given the small stove size and the lack of a chimney.

Ceramics/clay can also be used to create a stove. These have been used in India. As long as the basic concepts of smart stove design are followed, huge design variation is possible.