

Household energy saving technologies

Introduction:

The preparation of food requires heat, which is, in the context of a Malawian village, generated by burning firewood. The growing number of households is resulting in an overuse of the village forest areas, leading to deforestation. Firewood is becoming increasingly a commodity with a commercial value. Depending on the season, a household in the IFSP impact area has to invest up to 10 MK per meal just for firewood. For some dishes, the cost of firewood required for the preparation is exceeding the cost of the actual ingredients. As a consequence, villagers partially have abandoned the preparation of firewood intensive food (e.g. beans).

Already by applying some basic rules on food preparation (using a lid on the cooking pot, use dry firewood, cut the wood in smaller pieces...) the fuel consumption can be reduced. By growing some trees on your own land you can generate your domestic fuel wood demand at no cost.

The use of energy saving stoves (mobile or fixed) can reduce the fuel consumption by a large percentage. Based on simple pottery skills and local materials (clay or mud soil), the adoption of this technology is only dependent on the readiness of people to invest a little time to make their own stove.

Modules

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Lessons learnt

1. ECONOMY is more convincing than ECOLOGY

The ENVIRONMENTAL arguments have a high importance for the justification of the promotion of energy saving technologies in the academic arena. But in the field of development work in poor communities, they do not really achieve the required relevance to motivate food insecure households to change their mode of cooking. It is more important to demonstrate the ECONOMIC advantages of fuel wood saving technologies, to improve the accessibility and affordability of these technologies on village level. Adoption figures in the IFSP impact area prove that great changes can be achieved if the right arguments are applied. A survey from February 2002 revealed that more than 24,000 stoves were used in IFSP villages.

2. Saving-advantages are big enough to transform stoves into a commodity

Over time it turned out that some households prefer to buy a stove rather than to make it themselves. Hence the fuels saving stoves have even developed into a commodity which is sold even to households outside IFSP impact area. IFSP is supporting this tendency by promoting kilns for energy saving stove firing for larger productions.

Household energy saving technologies	
Module 1:	Household energy training for promoters

FACTSHEET

Introduction:

Issues of household energy interventions require a specific knowledge about the fire and how it is working. Otherwise extension can not be based on understanding. People would otherwise just follow instructions without knowing why they are supposed to do anything. IFSP asked Vivienne Abbott, a household energy specialist, to develop and implement both a training concept for agricultural extension workers as well as village promoters. The training manual for the extension workers is more comprehensive and was covering the program for two days. This document is used as the fact sheet for this module.

The description for the training of promoters is adjusted to the requirements on village level and is therefore very well suitable to be used as a session guideline in this module.

This manual, which also was given as a handout to all extension workers, can not include all the details of the different areas covered. Some of the information are further elaborated in the more technical modules on the stove design (module 4 and 5). This script gives you an overview on important issues to be considered and some insights in important issues.

Stove technical training for extension staff

from Vivienne Abott

The aims of this two-day training course were that participants should;

1. learn the basic theory of combustion and heat transfer
2. learn how a stove works and what makes an efficient stove
3. identify the socio-cultural factors affecting adoption and use of improved stoves
4. develop design/selection criteria for improved stoves for Mulanje area
5. learn the basic principles of making clay or pottery stoves
6. learn more about other stove designs, stove projects, and dissemination approaches.

Stove design theory and kitchen management **A two day training programme for extension staff / field assistants**

Background

This training is intended for extension staff or field assistants who are familiar with the area and the local culture and practices. The trainees are not expected to have previous experience or knowledge of improved stoves, although any such experience will be a positive factor.

Purpose of the training

The purpose of the training is to provide the trainees with an understanding of the technical aspects of stoves to enable them to train stove promoters, and to provide basic technical assistance on stove related issues.

By the end of the training the extension staff should;

- understand the advantages of the traditional three-stone fireplace and the reasons why it is so widely used
- understand the basic theories of combustion and heat transfer in relation to fuelwood burning stoves
- understand how a stove works and what makes a fuel efficient stove
- have identified the local socio-cultural factors affecting adoption of stoves
- have developed stove design (or selection) criteria appropriate for local conditions
- have applied this knowledge and constructed an efficient stove
- know the key kitchen management techniques for saving fuel

NB. These notes are intended as a guide for the facilitator/trainer, and also as a hand out for the trainees. To be handed out after the technical theory of stoves has been covered, because it is important that the trainees think through these processes themselves.

The training programme is structured as follows;

- Introduction
- Advantages and disadvantages of the three stone fireplace
- Technical theory of stoves
 - combustion (how fire burns)
 - heat transfer (how heat moves)
 - how to improve efficiency
 - how a chimney works
 - why multiple pot stoves are less efficient
 - one pot stoves
- Technical assessment of several different stoves
- Socio-cultural factors that affect stove adoption
- Developing design criteria
- Discussion on the dissemination approach and motivating stove promoters
- Discussion on stove building materials
- Practical stove building session
- Kitchen management techniques

1. Introductions

Participants have a opportunity to introduce themselves, to say why they are attending the training, what stove they use at home, whether they actually cook themselves, ...
The facilitator can explain the purpose of the training and the programme, then participants have an opportunity to add any additional realistic expectations or requirements.

2. Assessment of the traditional three stone fireplace

Participants compile a list of the advantages of the three stone fireplace.
The list should include most of the following;

- no cost
- easy to build, use and maintain
- easy to move
- accommodates different size and types of pots
- easy to light
- can use damp fuelwood
- can use large logs
- gives light and heat
- the cooks are used to using 3 stones
- strong for cooking nzima (or similar foods)
- can be used for many cooking purposes e.g. roasting, beer brewing
- others ?

Participants compile a list of the disadvantages of the three stone fireplace.
The list is likely to include the following;

- inefficient *
- smokey
- dangerous for cooks and children
- dirty, spreading ashes
- hot in kitchen
- others ?

NB.: The three stone fireplace is often not as inefficient as people assume. The efficiency will depend on how a stove is used.

The advantages list is likely to be longer than the disadvantages list because the three stone fireplace is in fact a very adaptable, good technology. This is why it is still so widely used in many parts of the world. We should not underestimate this traditional technology as we try to identify or develop an improved stove.

3. Combustion. How does fire burn?

There are 3 essential 'ingredients' needed for fire to burn;

- fuel (in this case fuelwood)
- oxygen
- heat

If any of these ingredients is not there in sufficient quantity the fire will not burn properly.

There are 4 stages of combustion of fuelwood;

Stage 1. When the fire is lit the initial heat is used to evaporate any water in the fuelwood at ~100°C

Stage 2. When the fuelwood is heated to ~2-300°C the volatile (or burnable) gases are released

Stage 3. The volatile gases mix with oxygen and the ignite (start to burn) when they reach temperatures of over 450°C. These gases burn with a yellow flame.

If there is not enough oxygen, or heat, or space and time (for mixing) these gases will not burn, and they will leave the fire as smoke. If this happens the fire may become so cool that it cannot burn and goes out.

Stage 4. When all the volatile gases have been released, then charcoal remains. If there is enough oxygen and enough heat the charcoal will burn at ~800°C. Charcoal burns with a red glow and a small bluish flame just above the hot coals. If there is not enough oxygen then poisonous carbon monoxide (CO) can be produced, instead of carbon dioxide. If the fire is not hot enough, the charcoal will remain unburned. If all the charcoal is burnt then only ashes will remain.

NB. All 4 stages are going on at the same time in different places in the fire. Only stages 1 and 4 happen in a charcoal burning stove.

Participants can light matches, and watch carefully to see the 4 stages of combustion.

The implications for stove design and use are;

- dry fuel gives better, more efficient combustion
- the firebox size and height is important to ensure space and time for the volatile gases to mix with oxygen and to burn
- a small hot fire gives better combustion provided there is enough oxygen
- there must be an outlet for the combustion gases and smoke so that a fresh supply of oxygen is drawn into the stove
- the firebox door must be large enough to ensure an adequate supply of oxygen
- a smokey fire, or a lot of charcoal remaining, or soot and tar over the fireplace or in the chimney are all signs of inefficient combustion, which means too little oxygen or heat or time was available
- others ?

4. Heat transfer. How does heat move ?

Heat is energy. The molecules in any substance are vibrating, and as that substance is heated the molecules vibrate more.

There are 3 modes of heat transfer; - conduction
- radiation
- convection

- Conduction is the movement of heat through a solid e.g. a metal spoon handle in hot porridge.

Conduction increases with - thermal conductivity of the material
- contact area
- temperature difference between hot and cold areas
- the closer the hot and cold areas are

NB. Conduction contributes mainly to the loss of heat to the stove walls and the firebox floor.

- Radiation travels in straight lines (like light), and needs no medium to travel through. When radiated heat reaches a surface it is either reflected or absorbed.
e.g. the heat from the sun.

Radiated heat increases with- temperature of the source ($\propto T_x T_x T_x T$)
- reduced distance to the heat source
- increased receiving area

NB. Radiation is the most important form of heat transfer for getting heat from the fire to the pot. But it also contributes to heat losses. The yellow flames and the red glowing charcoal radiate heat to the pot, but also to the stove walls and to outside.

- Convection is the movement of heat in the flow of a gas or a liquid.
e.g. water heating in a pot.

As a fluid (liquid or gas) is heated it becomes less dense (lighter) and as it rises it is replaced by cooler fluid. This process is called natural convection. If you watch water heating in a pot, you can see this process. If you then take a spoon and stir the water, you have forced convection.

Convection increases with - increased temperature difference
- bigger surfaces
- faster moving fluid

NB. Convection is how hot gases and smoke leave a stove, and oxygen is drawn in. It contributes to loss of heat from the stove, and some heat transfer to the pot.

5. To improve efficiency.

- Ensure good combustion by making sure there is enough oxygen, heat, space and time for the fuelwood to burn properly. This involves the proper design of the firebox, the stove door and the smoke outlet to optimise combustion. Holes and spaces allow the volatiles to cool and leave the stove as smoke without burning.
- Maximise heat transfer to the pot - as radiation is the most important mode of heat transfer to the pot, we must maximise radiated heat to the pot by;
 - making sure most of the pot bottom can 'see the fire'
 - having a small hot fire directly under the pot
 - making sure the pot is close to the fire, but there is enough space for volatiles to burn

Convection of hot gases and smoke leaving the stove also heat the pot, so;

- make sure they pass close as possible to as much of the pot surface as possible

- Minimise heat losses to the outside and to the stove walls and floor;
 - keep the door small, but allow enough space for fuel and oxygen to enter
 - reduce heat loss to stove walls and floor e.g. by insulating the stove or
 - choose building materials and wall thickness to suit cooking times (see graph)
 - prevent the hot gases escaping too fast from the stove

6. How does a chimney work ?

A chimney works by convection. The hot gases at the bottom of the chimney rise up and air is drawn into the firebox through the door.

NB. An effective chimney can remove smoke from the kitchen. But it will also remove heat from the stove and therefore reduce the efficiency of the stove.

Other issues to consider when deciding whether or not to disseminate a stove with a chimney are;

- It is difficult to build an effective chimney on a mud stove. Most chimneys draw too much air through the stove, or not enough.
- Dampers can reduce heat loss through chimneys. But experience of disseminating mud stoves with dampers shows that dampers are seldom used properly.
- Care is required when building a chimney in a grass roof kitchen, or structure with wood in the walls. These are potential fire hazards.
- A chimney requires regular cleaning, and must be built so that it is possible to clean inside. Experience shows that households tend not to clean chimneys, which then become blocked and can be a fire hazard

Remember, a stove with no chimney still needs a smoke outlet.

7. How many pots can cook on one fire ?

Most people think that a stove with 2 pots on one fire (or even three pots) is more efficient. Unfortunately this is not true!

- A one-pot stove without chimney is usually more efficient than a two-pot stove without chimney.
- Using two x one-pot stove is more efficient than using a two-pot stove.
- Three-pot stoves are usually inefficient.

But why?

- a) Because radiated heat is the main form of heat transfer from the fire to the pot. If the second (or third) pot is further from the fire it cannot 'see' much of the fire.
- b) A small hot fire directly under one pot will give the most efficient combustion and the most efficient heat transfer.
- c) A bigger fire spread under two or more pots will either be cooler (and less efficient) or it will consume a lot more fuelwood (and be less efficient).
- d) Two-pot stoves and three-pot stoves are more difficult to build accurately, and are often poorly built and therefore inefficient.
- e) Two or three-pot stoves are often used with only one pot, which is inefficient.

8. One pot stove design (without chimney)

Firebox - shape must enable the cooking pot to see as much of the fire as possible
- shape will also affect stability of the stove
- size will depend on the pot size
- most important dimensions are the diameter, and the firebox height

Floor - helps contain heat and ashes, protects kitchen floor
- can be a separate component

Door - must be big enough to allow enough fuelwood and air to enter
- must not be so big that a lot of heat escapes

Pot rests - must be strong
- must ensure that there is space for the smoke to leave the stove
- must ensure that too much heat cannot escape
- must accommodate the biggest and smallest pots commonly used without leaving a big gap for heat to escape

Air holes - are generally not necessary if the door is the correct size

Grate - generally not necessary for a household wood-burning stove
- but can improve combustion (especially in the charcoal burning phase)
- can improve the controllability of the fire
- is essential for a charcoal burning stove.

9. Stove assessment

The participants have an opportunity look at several different stove designs, and to do a technical assessment of those stoves on the basis of what they have learnt so far.

10. Socio-cultural factors affecting stove adoption

A stove can only be efficient if it is used regularly and properly, and if it is maintained properly. Therefore to be efficient a good stove design must be well suited to local cooking habits, conditions and customs. Here are some of the issues that need to be considered;

- Who cooks? And what do they want from their stoves?
- What is the priority benefit they would want from a new stove?
- Where do they like to cook? Inside? Outside?
- What stove is most commonly used? What are its advantages?
- Does it have any important traditional significance?
- Is it used for space heating, for lighting, for other cooking purposes?
- What types/size of fuel are most commonly used? Bought or collected?
- What types/combinations of foods are most commonly cooked?
- Do they require vigorous stirring
- What is the average duration and frequency of cooking?
- What is the average household size?
- What types and sizes of pots are commonly used?
- How many pots are usually cooked at one time?
- How important is smoke removal compared to fuel savings?
- Do households use the smoke to store seed, or for any other purposes?
- What type of stove building materials are available?
- How much can households afford to pay for a new stove? Who decides?
- Who would build the new stoves? What skills would they need?
- What else do household require of a new stove? Smart, modern, durable?

This information can be used to develop design (or selection) criteria for a new stove. At least the following criteria need to be specified;

- ⇒ Type of fuel that will be burnt in the stove
- ⇒ The % levels of fuel saving that are anticipated in lab and field tests
- ⇒ Acceptable level of cost of the stove
- ⇒ Stove building materials
- ⇒ Dissemination method, who will build the stoves and the level of skills required
- ⇒ Which types, size and how many cooking pots are to be accommodated
- ⇒ Main types of food to be cooked and other uses of the stove
- ⇒ Whether smoke removal or reduction is a priority
- ⇒ Ease of use and maintenance
- ⇒ Other desirable attributes: stability, durability, portability, controllability, ...?

NB. Remember to be realistic. The final design is likely to be a compromise between the need for fuel saving and the other criteria such as stability, cost, simplicity, the use of different size and types of pots, etc...

11. Stove design or selection

The stove design criteria can then be used to design or select appropriate stove designs for testing. This step requires some expertise and experience of different stove designs, but it is important that the participants (the new stove practitioners) understand and appreciate the decisions and compromises that are necessary.

It is most important to ensure that the proposed stove design is appropriate to the proposed dissemination approach. If sustainable dissemination is the long term objective, it is important to consider the issues of sustainability in relation to the stove designs selected. For example; who will build the stoves and how will they be motivated in the long term? how will the quality of stoves be maintained and monitored?

12. Pottery stoves

Pottery is a brittle and fragile material and must be properly handled and moulded. The clay must be well prepared with no stones in it and no air bubbles. For stove production it is often necessary to have a clay with higher sand content than the clay used to make pots. If possible pottery stoves should be fired before they are used. But if firing is not possible, stoves can be made and used in their 'green' state. They will be less durable if they are not fired.

The walls of the stove need to be strong enough to support the pot, but if they are too thick they will not fire properly. The whole stove body should be of similar thickness, otherwise it may dry unevenly and crack. Also when cutting doors make sure the corners are rounded because sharp corners can result in cracks.

Remember that clay shrinks as it dries. Most natural clays will shrink approximately 10%, therefore stove should be made approximately 10% bigger than the ideal dimensions to allow for this shrinkage. The pottery stoves must be very well dried before firing, otherwise they will break during firing.

13. Stove building practical

The next step is to build the prototype stoves designed or selected using the design criteria. It is important that the participants get their hands dirty and apply the knowledge that they have acquired during the training.

These stove designs would then need to be tested and modified as necessary, but this component could not be covered in this training course.

14. Improved kitchen management

There are a number of simple kitchen management measures that can save as much fuelwood as an efficient stove:

- cutting, splitting and drying fuelwood
- preparing food before lighting the fire
- cutting food smaller and pre-soaking dried foods such as beans
- using less fuelwood in a small hot, well managed fire
- using a lid on the cooking pot
- reducing the fire and simmering food once it has boiled
- extinguishing the fire immediately after use
- using and maintaining a fuel efficient stove properly

Household energy saving technologies	
Module 1:	Household energy training for promoters

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The fact sheet contains the training manual for extension worker. This extension guideline comprises the hand-out for the training of village based promoters. It can also be used for the training of village committees or other interested community members.

Expected output: “What shall the trainees be able to do?”

Participants shall have a basic understanding of household energy issues and can relate them to their own practices.

Sequence of sessions: “How to achieve the output?”

Manual for a “one day training”. Please contact a professional trainer for assistance in the starting phase of this intervention.

One Day Training for Stove Promoters on Stoves and Kitchen Management

Background

Stove promoters are the key people in the development and dissemination of appropriate stove technologies. It is important that they understand how stoves work and what makes an efficient stove. Stove technology in this area has already evolved from the very early ‘massive’ two-pot mud stoves which were not popular, to the simple fixed one-pot stoves introduced from Tanzania, to the portable clay and pottery stoves now being piloted.

Purpose of training

The purpose of the training is to increase the stove promoters’ understanding of the basic technical aspects of stoves, and other methods of saving fuelwood.

The stove promoters will learn:

- what makes an efficient stove
- why one-pot stoves without chimneys are more efficient than other more complicated designs
- how to improve the operation and efficiency of the existing stove designs
- about other ways of saving fuelwood

The Training Programme

This is an outline of the training, but the facilitator is not expected to rigidly follow this outline, rather s/he is expected to use their skills and experience to draw the participants into this process, and to make sure that essential information and knowledge is shared. There is a simple handout in the vernacular which should be distributed after the training.

1. Each participant is asked to introduce themselves and say why they are there.

Facilitator should explain the purpose of the training, and give participants an opportunity to add other relevant topics if they wish.

2. The facilitator initiate a discussion on the following question;
“What do women want from their stove?”

The discussion should be facilitated in order to cover at least the following areas;

- Functional needs
- fuels most commonly used (type and size)?
 - types of food commonly cooked ? duration of cooking ?
 - number of meals cooked each day ?
 - type and sizes of pots commonly used ?
 - other cooking, heating or lighting functions required ?
- Expected benefits
- fuel savings and their expected effects ?
 - cooking convenience ? and speed ?
 - safety ? hygiene ?
 - other benefits? any expected disbenefits ?
- Other factors
- how the stoves should look ?
 - size ?
 - cost in terms of cash or labour ?
 - durability ?
 - skills required for using the stoves ?
 - maintaining the stoves ?
 - other issues ? e.g. portability

3. The stove promoters should then be requested to rank key expected benefits in order of importance.

4. The facilitator should then initiate a discussion on the following question;
“What are women saying about the fixed mud stoves and new portable stoves?”

The discussion should draw out both the positive and negative aspects of these stove designs, and find out whether households with the new stoves still use the 3 stone fire for certain things.

5. The facilitator should pose the question;

“How does fire burn ?”

Then using familiar examples explain the 3 ingredients that fire needs to burn :

- fuel (wood)
- enough air - blowing on the fire to get it burning
- enough heat to start burning and to keep burning
 - using a match or burning stick to give heat to start the fire
 - pulling sticks away from the fire to cool it and extinguish it

Explain that if any of these ingredients is missing the fire will not burn.

Then explain the 3 stages of combustion :

- First the heat chases away any moisture in the fuelwood.
- Then the wood releases gases (*mafuta*) which mix with the air and burn with yellow flames giving off some heat. But there is not enough air or heat or time or space the gases will leave the fire as smoke.
- Finally the remaining charcoal burns with a red glow (and tiny blue flames) giving off a lot of heat. But if there is not enough air going into the fire, or if the fire is not hot enough the charcoal will not burn.

All three stages are happening at once in a fire.

If possible these stages can be demonstrated by participants observing how a match lights and burns.

Participants should know from experience that if hot charcoal and burning wood are close together the fire will burn well with little smoke. But if the fire is spread out it will become smokey and can die. A small hot fire will give most heat from less fuelwood, so is more efficient than a big fire.

6. The facilitator can then pose the question:

“How do we make sure that more of the heat reaches the cooking pot ?”

and make sure the following points are discussed and understood.

- A small hot fire directly under the pot will give the most heat to the pot.
- The pot only gets enough heat if it can ‘see’ the fire and if the fire can ‘see’ the pot. So make sure that as much of the pot bottom as possible can ‘see’ the fire.
- If the cooking pot is too far from the fire it will get less heat, but if it is too close the fire will not burn properly. So the firebox must be the right height.
- The stove door must be big enough for the fuelwood and to allow enough air into the fire. But if the door is too big it will allow too much heat to escape.
- There must be a place for the smoke and combustion gases to leave the stove, otherwise there will be no room for fresh air to enter the fire.
- Smoke and heat and flames like to flow like water, but they flow upwards. The heat and the flames will try to follow the smoke, so it is better if the smoke leaves the stove close to the cooking pot.

7. Can we put two pots on one fire ?

Most people think that cooking with two pots (or three pots) on one fire will save fuel.

THIS IS NOT TRUE!

The pots only get enough heat if they can see the fire. So the cook will need a bigger fire using more fuelwood to heat more pots.

One-pot stoves are more efficient than two-pot stoves.

8. If willing some of the participants and/or extensionists can perform a role play on kitchen management.

The story outline is about two women, each preparing a meal for her family. One is organised, she prepares all her food before lighting her stove, her fuelwood is all ready cut and dried. She lights her fire and starts to cook, as soon as her pot boils she reduces the fire, puts a lid on her food and simmers it carefully until it is cooked. She extinguishes her fire, puts a pot of water on the stove to warm, and her meal is ready.

The other woman lights her stove but the fuel is not cut or dried so she uses very big logs. Then she chats with her neighbour before preparing her food. The she rushes to get her food cooked and using a lot of fuelwood, and producing a lot of smoke. Her husband comes home before the meal is ready. She forgets to extinguish her fire.

When the role play is finished, ask the participants to list the ways to save fuelwood:

- cutting, splitting, storing and drying fuelwood
- cutting food into smaller pieces so it cooks faster
- soaking dried foods, like beans
- preparing the food for cooking before lighting the fire
- keeping a small hot fire directly under the pot
- reducing the fire once the food is boiling, and simmering the food
- using a lid, and even putting a stone on the lid
- putting the fire out immediately cooking is finished, and use the remaining heat to warm some water

Using and maintaining an improved stove properly will also save fuel too !

9. The next session is the practical, where participants should be divided into smaller groups which will make a one-pot pottery stove using the technical information learnt

10. The final discussion should cover the following;

- the one-pot stoves, and the modifications to existing stove designs
- whether or not to fire the pottery stoves other stoves e.g. the liner stoves,
- the information / extension messages that need to be given to the stove users
 - to light a small fire the first time the stove is used
 - how to use the stove properly
 - how to maintain the stove properly
 - other ways to save fuelwood
- the need for assessing the stoves, and for **testing** the stoves.

Household energy saving technologies	
Module 2:	Firewood management

FACTSHEET

Introduction:

Firewood is a valuable source of energy, whether it is being collected or bought on the market: it involves financial or time resources of the household to obtain it. Even without switching to an improved stove, with the application of firewood management techniques, the amount of firewood needed for the daily cooking requirements of a household can be reduced.

And the best is: these techniques involve no risk and no cost!

Proper firewood management can save approximately 20-30% of the total requirement. If trees are planted around the house, the costs involved in the provision of firewood can be reduced to the small investment for the seedling.

Otherwise, there are no costs involved in the adoption of these recommendations. Therefore the households can spend the money they save for buying food, soap, medical services etc. and time not invested for firewood collection can be used for working in the gardens or family care (e.g. looking after children, sick and elderly people).

The following recommendations address mainly the aspects:

1. The drying and preparation of firewood before use
2. The management of firewood during the cooking process
3. Diversification of the types of biomass fuels used as alternatives to firewood



Firewood sold on the market in small bundles



A small headload of firewood collected.

These recommendations to save fuel are addressed to firewood user. For charcoal users these techniques do apply in another way. Keeping charcoal in a dry place and supplement it with other locally found fuels are techniques also applicable for charcoal users.

1: Practices for better storage and preparation of firewood

One part is to get rid of the water in the fresh firewood before you start using it in your kitchen.

With the change to firewood access through commercial structures or long distance collection, households tend to have no stocks of fuel wood at home. They basically just get today what they need tomorrow or within the coming week. This short term supply system has severe disadvantages:

- **Loss of energy:** freshly collected firewood contains a lot of water. In the burning process, this water first has to get out of the wood before the actual heating process can start. App. 25-35% of the energy is wasted if the firewood is not dried before use.
- **Smoke:** freshly collected firewood develops a lot of smoke when used in a fire. It is a health hazard.

Recommendation 1.1: Use smaller pieces of firewood

How to do it: Cut your firewood in smaller pieces (e.g. 2 fingers thick)



Why does it save firewood?

- Smaller pieces of wood take less time to dry.
- They also dry out more comprehensively than bigger pieces.
- Smaller pieces burn better, because they have a bigger surface and better contact with the air that is necessary for the burning process.
- You can adjust the firewood input to the fire better if you use smaller pieces instead of bigger logs and therefore you can optimize the use and avoid wastage.

Other benefits

- You can use as well other parts of a tree, not only the big branches or the stem. Even smaller twigs can be used.
- This is an advantage for elderly and sick people who have problems transporting big headloads or heavy logs of firewood.

Recommendation 1.2: Dry firewood very well in the bright sun

How to do it

Let the firewood dry in the bright sun or inside your kitchen for at least several days.



Why does it save firewood?

Freshly cut wood contains a lot of water, it is wet. When the firewood gives a hissing sound when burning, it means that there is still water evaporating by the heat generated through the fire. This process consumes energy that is lost to heat up your food. If you let the sun do that work of drying, the full energy content of the firewood can be used to heat what is in the pot. You will make more efficient use of the firewood and therefore use less.

Other benefits

Dry firewood will burn cleaner and cause less smoke.

Smoke is a health hazard! It increases the risk of respiratory infections and eye infections. Smoke of fireplaces can be more dangerous than smoking cigarettes.

Benefit: Less smoke means less (indoor) air pollution. Less air pollution means less health hazards for anybody close to the stove: the person who is cooking, babies on the back of their mothers bending over a stove, or children playing close to the stove.

Recommendation 1.3: Store a stock of firewood in a dry place



How to do it

- Store the dried firewood under a waterproof shelter, guarded from rain and splash water.
- If you have a kitchen, store it inside the kitchen to make use of the heat emitted by the fireplace. The most adequate solution is to hang a simple rack under the roof, as the heat rises upwards. It also has the advantage that it does not take up space in the kitchen.

Why does it save firewood?

Firewood still keeps on losing moisture, even if it feels dry. Ideally firewood should be left at least for three weeks, better for two months to dry out properly before being used. The drying process continues even if the firewood is stacked. The drier the firewood the better the use of the energy contained in the wood. All the energy of the firewood can be used for the cooking process instead of removing surplus moisture in the firewood.

Other benefits

If you store the firewood in your kitchen, it is always at hand when you need it

Many households might have problems to afford buying an amount of firewood at once in order to allow it enough time for proper drying. The solution is to use the firewood saved through the application of the new skills to build up a bigger stock over a certain period of time

Example: If a family normally uses 10 sticks of firewood for a meal and can save two sticks per day, they can increase their stock over a month by two sticks per day. This means that after one month the family should have a stock of 60 sticks of firewood without spending more money than they did before. By doing so, they build up a stock of firewood without any additional financial requirements.

2: Better management of firewood in the stove while cooking

You can prepare very different quantities of food with the same amount of dried firewood. It all depends how efficient you manage your fire while you are cooking. Here are some recommended practices compiled that can assist households to improve the use of their firewood.

2.1: Start the fire with 3 sticks of firewood only



How to do it

Use your usual method to light a fire, but try not to put more than 3 sticks of firewood in the stove

Why does it save firewood?

If you use a stove, it will take a bit of time until the stove is hot. During the heat-up phase the stove will absorb heat from the fire. Once it is hot, the fire will burn well and the stove will not 'steal' more heat from the fire, but the heat will go mainly to your pot. For heating up the stove in this initial phase, 3 sticks are enough. By restricting the number of sticks at the beginning, you can avoid wasting surplus firewood.

Comment

This mainly applies to the user of improved stoves, but to a certain degree it also helps the user of the traditional 3 stone stoves.

2.2: Once the fire is going, remove surplus firewood



How to do it

When the fire is well established and the food is boiling, take a stick out of the fire and put it aside next to the stove. Add it only when you need more heat.

Why does it save firewood?

Once the stove is hot and the fire is burning well, the fire does not need so much firewood any longer to maintain the same heat.

When you cook food that takes quite a long time to cook e.g. like beans, during the simmering phase sometimes even one stick of firewood is enough to maintain the slow heat.

By monitoring the fire and 'feed' it with the right amount of firewood, you can minimize the use of firewood and avoid waste.

Other benefits

Slow heat prevents the food from burning and therefore avoids the spoilage of food.

2.3: Keep firewood after cooking for further food preparations



How to do it

When you remove the pot from the fire, take the remaining fire-wood out of the stove, extinguish the flames and keep the firewood for the next time you cook. Make sure it is cool before you put it next to things that might catch fire. The best is if you stick the firewood in a pile of dry sand or ash. It helps to extinguish the fire and reduce the smoke. If the sand is dry, the firewood will light easier next time you need it.

Why does it save firewood?

Normally any remainders of firewood are left in the stove and they end up being burnt and wasted without further use unless you take the stove inside for space heating. Once you have finished cooking and the pot is no longer on the stove, there is no need to keep the fire burning. This firewood can still be used (saved) for the next time you cook. You will then not need so much new firewood.

3: Use other biomass as alternatives to firewood

Especially if you have an improved stove, it is easy to complement the firewood with other biomass fuels that help to reduce the overall firewood needs of a household. That can be small twigs collected from the surroundings of the house, crop residues like stalks, cobs, waste materials from the garden like dry bark or pods from trees, cut-offs after trimming hedges like bamboos.

Just make sure the material is well dried. In the photo below, you can see the difference between the freshly collected pigeon pea stalks (in the front) and the properly dried ones (where the matchbox lies).



Household energy saving technologies	
Module 2:	Firewood management

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The intervention is targeted for village communities which have indicated in a PRA (or any other assessment process) that access to firewood is a problem. The outlined sessions therefore come as a response to a self-targeting of the community.

It is important to have both women and men in the meetings. Women are usually in charge of firewood collection and are managing the fire while cooking, whereas men usually have to procure firewood if local access is not possible.

Expected output: “What shall the trainees be able to do?”

Households shall be able to save firewood through the application of better firewood management. They can explain the benefits of the improved practices and why it is working.

Sequence of sessions: “How to achieve the output?”

- Session 1: Analysis of the “Access to firewood”-problem and local coping methods (and their impact).
- Session 2: Save firewood through better preparation and storage
- Session 3: Save firewood through better fire management
- Session 4: Sensitization for individual firewood growing

The actual training for individual tree planting (e.g. how to raise seedlings, how to plant trees, how to do the pruning etc. will not be described in this module as it is rather done on an individual level through the village forestry promoters.

Tabular session guides: Session 1 (Problem Analysis)

To SEE

Steps	Tools	Group	Materials	Time
Starter	Role play: "No food preparation without firewood" A man brings a lot of food items home and is expecting a good meal to be prepared by his wife. But there is no firewood for preparation. The wife complains that because she had to prepare beans yesterday, all her firewood is gone and there was no time to go as far as the forest reserve to collect new wood. She calls the husband a fool because he spent all the money for food and did not let any money for buying firewood on the market. Hence they end up not eating despite the food in the house.	all	Food items (e.g. maize, tomato, beans etc.)	10 min.
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like this? ⇒ What can we do to improve?	Small groups,	Paper, pen	30min
Sharing	How is the situation of the play in this village? ⇒ Can this situation happen in this village? ⇒ Who collects firewood and where? ⇒ Who buys firewood and where?	all		15 min

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	How was the situation in the past? Why did the problem develop? ⇒ De-forestation, population growth... What have you done so far to cope with the problem? ⇒ Collection in forest reserve, buy firewood on market, avoid long cooking times, reduce number of food preparations) Did it help you? What are the consequences? ⇒ less time for household, less money for food, less food intake Calculate cost of firewood for one meal	all		45 min
Additional aspects from the facilitator	What else can be done to avoid the negative consequences of the local solutions? ⇒ Use firewood more efficient ⇒ Improve local access to firewood	all		10 min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Self-targeting: Those who are interested may participate in the next sessions, agreement on date and time for next sessions.	all		10 min

Tabular session guides: Session 2 (better storage and preparation of firewood)

To SEE

Steps	Tools	Group	Materials	Time
Starter	experiment: ⇒ give groups one dry and one fresh stick of firewood (equal wood and size) for comparison; Mark them with a label as “A” (dry) and “B” (fresh); ⇒ light a fire in a local stove (use dry wood); ⇒ ask each group to come forward and to hold both sticks in the flames and compare the burning process of each stick for 2-3 minutes and give way for the next group.	Small groups	Local (3-stone) stove, dry and fresh firewood	15 min.
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like this? ⇒ What can we do to improve?	Small groups,		30 min.
Sharing	How do stick A and B compare in the fire? ⇒ Bubbles, gas, hissing sound, slow fire, smoke, more yellow than blue flames,... at the fresh stick (B); Did you observe this when you prepare you food?	all		15 min

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	What do you think is the reason for the observation? ⇒ Moisture in fresh firewood What impact has moisture on the fire? ⇒ Some of the energy of the firewood is used to move the water out of the wood; ⇒ Therefore the fire does not burn well; ⇒ You need more wood for the same cooking; ⇒ There is more smoke;	all		45 min
Additional aspects from the facilitator	What can be done to avoid the negative consequences of fresh firewood? 1. Dry the fresh firewood in the sun before use; 2. Split firewood for faster drying ; (smaller pieces dry faster than thicker firewood) 3. Store sun-dried firewood in a dry place at your house for several weeks (it takes long until firewood is really dry)	all		10 min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Participants explain if they feel they could apply these recommendations at their homes	all		15 min

Tabular session guides: Session 3 (better fire management in food preparation)

To SEE

Steps	Tools	Group	Materials	Time
Starter	Experiment/roleplay: ⇒ Two groups of village promoters (or instructed volunteers) receive equal inputs for food preparation (e.g. 3-stone stove, 10 sticks of firewood, cooking pots, ingredients). ⇒ Before they start preparing the food, this fact has to be publicly established (e.g. counting the sticks of firewood). ⇒ They prepare parallel the same amount of food. ⇒ One group is applying all recommendations perfectly, the other one makes all wrong; ⇒ At the end of the food preparation, the remaining firewood is counted again publicly to assess the difference. (The food can than be eaten)	all	2 Local (3-stone) stoves, 10 sticks of firewood for each stove (equal size); ingredients for food preparation (e.g. maize flour, typical local relish)	60 min.
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like this? ⇒ What can we do to improve?	Small groups,		30 min.

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	What is the difference between the 2 groups? ⇒ One group is faster, the other one is remaining with more firewood in hand; What do you think is the reason for the observation? ⇒ You can reduce the number of sticks in the cooking process;	all		15min
Additional aspects from the facilitator	In the cooking process, you can differentiate phases which require different amount of heat: ⇒ Heating up to boiling point (needs a lot of heat) ⇒ Simmering (needs little heat) ⇒ Stirring (needs a lot of heat) Accordingly, you can add or remove sticks in the fire.	all		10 min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Participants explain if they feel they could apply these recommendations at their homes	all		15 min

In IFSP practice, this session was combined with the demonstration of better cooking practices (see module 3)

Tabular session guides: Session 4 (individual firewood growing)

To SEE

Steps	Tools	Group	Material	Time
Starter	Roleplay: "A tree is like a chicken" A young boy meets his grandfather and asks him, why there are no trees in their village. The old man answers that young men have forgotten that "trees are like chickens". Then he falls a sleep. They boy does not understand the grandfather and asks the participants for an explanation. After discussing several possibilities of what it may mean, the grandfather wakes up and can be asked by the boy and the participants. He than explains that there are 2 ways to benefit from a chicken: ⇒ The shortsighted man waits until its old enough and eats it. His stomach will soon be empty again, but he is left with nothing. ⇒ The clever man takes good care of that chicken. It will give him many eggs, out of which he can raise more chicken. If he manages them properly, he will never be again without chickens.	all		15 min.
Self discover y	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like this? ⇒ What can we do to improve?	Small groups,		30 min.

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	What does the old man mean when he says that "trees are like chicken"? ⇒ You can raise trees ⇒ You can benefit of them (cut branches) without destroying them (cutting the stem); ⇒ You can grow new trees out of old trees (raising seedlings out of seed); ⇒ If you manage them properly, you will never be without trees. What happened to the trees in your village? What did you do about it?	all		45 min
Additional aspects from the facilitator	The village based forestry promoter is introduced to the community. He explains that he is willing to assist anybody who is willing to grow and manage his own firewood trees on his own land.	all		10 min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Participants discuss with forestry promoter about individual training arrangements.	all		15 min

Household energy saving technologies	
Module 3:	No-cost Kitchen management techniques

FACTSHEET

Introduction:

Many households do not use their firewood or charcoal efficiently in the cooking process. The fuel is wasted because of unsuitable cooking procedures.

Charcoal is a fuel accessed on the commercial markets, especially in urban areas. The lack of local access to firewood has turned it into a commodity as well in many areas. A commodity requires cash to access. It therefore means that if households want to save money for other things or they have a cash constraint that impedes them from accessing the fuels, one option is to apply no-cost techniques on how to use this fuel in a more efficient way by managing the kitchen and the cooking process in a better way. This will allow households to use the commodity as efficient as possible. This can partially be done by following some very simple practices which do not involve any costs.

The main techniques address the following topics

1. A planned approach to cooking
2. Techniques during the cooking process
3. Techniques at the end of the cooking process

1: A Planned approach to Cooking

1.1: Have all ingredients and tools together before you start the fire



How to do it

Plan ahead and think about what you need. Get all the utensils you need: pot, lid, spoon to stir etc.

Anything that needs to be added to the dish should be next to your stove: all raw ingredients washed and already cut up, salt and spices etc should be ready and in reach before the fire is lit.

Why does it save fuel?

If you concentrate on the cooking and you keep the time the fire is burning as short as possible, you will need less firewood or charcoal.

1.2: Cut all ingredients in small pieces		
		<p>How to do it Don't boil a big potato or cassava root in one piece (left). Cut it up into smaller pieces (right), it will cook faster and use less fuel.</p>
<p>Why does it save fuel? Smaller pieces cook quicker than bigger pieces, because the surface exposed to the hot water is bigger than for a big piece. It takes less time for the water to heat up a smaller piece than a bigger piece.</p>		

1.3: Shorten the cooking time of food	
<p>How to do it</p>	<div style="display: flex; justify-content: space-around; align-items: center;"> <div style="text-align: center;"> <i>Unsoaked beans</i> </div> <div style="text-align: center;"> <i>soaked beans</i> </div> </div> <p>Soak dry food before you cook it until it is already a bit soft. Soak e.g. dry legumes and dry cassava over night.</p>
<p>Why does it save fuel?</p>	<p>Reducing the cooking time reduces the time the fire burns and reduces the consumption of firewood.</p>
<p>Comment</p>	<p>You can also add alkalis out of ashes to shorten the cooking time of some food. This will also add valuable micronutrients to you food.</p>

1.4: Use your stove rather for one continuous longer period rather than for several shorter times	
How to do it	<p>Cook all dishes of a meal on the same stove one after the other. Don't let the stove get cold in between.</p> <p>Use only one stove at a time and don't have two fires burning at the same time.</p> <p>Cook for all household members at the same time.</p>
Why does it save fuel?	<p>Every time you start the fire in a stove some energy will be used to heat up the stove. When the stove cools down after the fire is out, the heat retained in the stove goes into the environment with no use.</p> <p>If you cook all the dishes of a meal consecutively on the same stove while it is already hot, you save this extra bit of firewood that is otherwise needed to heat the stove up again.</p>
Comment	<p>Avoid unnecessary reheating of food. Plan your preparation time in accordance with the time people want to eat. Thus food can be taken directly from the stove without reheating. You save more firewood.</p>

2: An efficient management of fire in the cooking process

2.1: Don't waste time once the fire is started	
	<p>How to do it Concentrate on the cooking and don't get distracted chatting with your neighbor while the fire is burning. Put the pot on the fire as soon as it is well established.</p>
<p>Why does it save fuel?</p>	<p>The shorter the fire is burning, the less firewood it consumes.</p>
<p>Other benefits</p>	<p>Paying attention to your food during the cooking process can prevent wastage of food (burning; dogs ...)</p>


2.2: Cook food in the smallest possible amount of liquid	
<p>How to do it</p>	<p>Use just enough liquid for the food that it can get steamed. Most of the food does not need to be 'floating' in boiling water.</p>
<p>Why does it save fuel?</p>	<p>Using less liquid means having to bring less amount of water to the boiling point. Therefore you need less firewood or charcoal to get the food cooked</p>
<p>Other benefits</p>	<p>When you use less liquid for cooking, you don't have to throw away surplus water after cooking. Food always loses some nutrients to the water it is boiled in. By throwing away surplus water after cooking you also throw away nutrients from the food</p>

2.3: Prevent surplus steam to escape	
	<p>How to do it</p> <p>Keep a lid on the pot. The lid must be closing well enough not to let too much steam out.</p>
<p>Why does it save fuel?</p> <p>Any steam or vapor that escapes from the pot is water heated up to boiling point and passing from liquid water into gasified steam by using energy coming from your firewood. Preventing the loss saves fuel.</p>	
<p>Other benefits</p> <p>Steam building up inside the pot without being able to escape helps to cook the food inside the pot quicker.</p>	

2.4: Monitor the heat of the fire	
<p>How to do it</p> <p>As soon as the food is boiling, take out one stick of firewood</p>	
<p>Why does it save firewood?</p>	<p>When the food has reached boiling point, no more increase in heat is needed. You need only enough firewood to maintain the heat at the boiling point. A small fire will do. By taking out a stick you save it. This does not apply to charcoal users.</p>
<p>Comment</p>	<p>During the simmering phase when the stove is already hot, agricultural residues (maize cobs, pigeon pea stalks etc.) or fuels that don't ignite easily (like husks) can be used to substitute firewood in a stove with a sheltered fire chamber.</p>

2.5: Do not overcook food	
How to do it	Monitor the cooking process closely by testing regularly if the food is already cooked.
Why does it save fuel?	Reducing the cooking time reduces the time the fire burns and reduces the consumption of fuel
Other benefits	Some Vitamins get destroyed by heat. Shortening the cooking time will help to preserve the maximum amount of Vitamins. Your food will be more nutritious and supply more essential Vitamins.

3: Use remaining heat of stove after cooking is finished

3.1: Make use of the hot stove after cooking food	
How to do it	 <p>If you have finished cooking the meal, put a pot with some water on the stove. Put a lid on the pot.</p>
Why does it save fuel?	Instead of using extra fuel only to warm up water for bathing you can make use of the retained heat in the stove and save fuel for other purposes. If the timing is not right, think about possibilities to change your time schedule.
Other benefits	You can have warm water for bathing or washing without extra fuel used.

Household energy saving technologies	
Module: 3	No-cost Kitchen management techniques

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

All interested community members who are involved in cooking.

Expected output: “What shall the trainees be able to do?”

Community is able to prepare food with less firewood.

Sequence of sessions: “How to achieve the output?”

The centerpiece of the extension for this module is a roleplay in which all recommended practices are demonstrated. It can be combined with a cooking competition for the comparison of the benefits.

Under IFSP, these plays were developed by the village based promoters of neighboring villages, who then performed in the sessions in each of their villages together. It can also be done by other volunteers or extension workers.

We think it is important that the play is locally developed on the basis of the described recommendations (see factsheet). This promotes the best possible adjustment to the local conditions of food preparation. Below, some few examples of possible plots are sketched for your inspiration:

- (a) A woman receives a visit of her friend who asked her why she did not attend the training on kitchen management. She complains that her husband did not allow her to participate because he feels it's a waste of time. Her friend, who attended the meeting, suggests that they should just prepare some food together so that she can explain her all the recommended practices. After the preparation the ladies can not believe how little firewood they needed. Just when they discuss the observed benefit, the husband arrives for his dinner. When he learned about the savings, he is so happy that offers her a chitenje and the promise never to stop her again from attending a project meeting.
- (b) A wife complains to her husband that she has no firewood. The husband asks angrily why she needs so much more firewood than her neighbors. He then leaves the house threatening that he will have to reduce on food expenditures if they can not cut the costs of firewood. The alerted wife approaches the village based promoter for advice on better kitchen management. They agree that the promoter will visit her when she is preparing the next dinner. The promoter asks the wife to start preparing the food as she is used to do it. Step by step, all bad habits and mistakes are revealed and the promoter explains what can be done differently according to the recommendations. The wife realizes how much firewood she can save even with one preparation. When her husband arrives for dinner, they celebrate the firewood savings.
- (c) Two teams start a cooking competition. Both teams have equal amount of resources. One team is very firewood sensitive, the other one is doing all things that can “help wasting firewood” (e.g. while the fire is on starting to beg food inputs from the participants of the training...). At the end of the competition, the firewood consumption is compared. The participants are then asked to find out how these savings were achieved.

To SEE

Steps	Tools	Group	Materials	Time
Starter	Roleplay (with cooking demonstration or competition)	all	Food, stoves, firewood	15 min
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like this? ⇒ What can we do to improve?	small groups		30 min
Sharing	What did you see that has helped to save firewood in this cooking process? (list all observed practices as they come from participants)	all	Flipchart paper, marker pen	20 min

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	Why are these practices assist to save firewood? ⇒ Discuss all listed practices, explain effect, modify or correct mistakes in the observation. ⇒ Add other observations which the participants failed to see, and explain why they work.	all	Flipchart paper, marker pen	30 min.

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	What can stop you from applying these recommendations for today's dinner preparation? Promoters agree that they can be approached any time if someone needs more explanation on recommended practices.	all		10 min

Household energy saving technologies	
Module 4:	Retained heat cooker (‘fireless cooker’ or ‘food warmer’)

FACTSHEET

Introduction:

The fuel consumption in the process of food preparation on a fire is not constant. A lot of fuel is required to heat up the content of a cooking pot. Once it is boiling, it only takes little energy to keep it hot and maintain the temperature at boiling point. Some foods like legumes, (sweet) potatoes, cassava, rice or green pawpaw etc. do not require any stirring. The content of the pot has to be heated once to the boiling point and then kept at simmering level on a little flame without having to open the lid of the pot. If you open the lid of the pot and stir the content, the temperature goes down quickly and more fuel is needed to get it back to boiling. The small fire basically replaces the heat that is lost to the environment through the surface of the cooking pot and the closed lid. If you don't use a lid, the heat loss will be even bigger and you more fuel.

How does a fireless or retained heat cooker work?

So there are two ways of maintaining the heat in the cooking pot: either by adding energy through a slow fire or by preventing the heat to escape from the cooking pot: instead of keeping the pot for a long time on a small fire, you can also wrap the cooking pot in an insulative cover (heat retainer = fireless cooker) which prevents the heat to leave the pot. The simmering process of the meal continues inside the wrapping. No further external heat supply is required. Based on the experience of the cook with cooking times of the specific foods, the food stays in the heat retainer (fireless cooker) until it is served.

Food can be kept warm even for up to 6 hours if people come back late home from the field or the market.

Or if visitors are expected and they don't come in time, the buffet can be kept warm, decorative baskets can be put directly on the table (see photo). It is not advisable to keep the food longer than six hours. Otherwise it might promote the growth of microorganisms in the food which puts the health at risk. The underlying principle of insulation is that air does not conduct heat as well as solid metal (e.g. a cooking pot), water or soil. The more insulated pockets of air you can create between the cooking pot and the outside, the more heat will be retained inside the pot.



Food warmers used to serve a buffet

Keep cooking with retained heat after removing the pot from the fire or simply keep food warm

Applicable for all fuel types (firewood, charcoal, paraffin, LPG, electricity etc.)

How to build a fireless cooker:

Insulation: These air pockets can be created with many local materials. But it is important that no moisture is in the wrapping, as water increases the heat conduction. You can use dry grass (hay), dry banana leaves, maize stems, vetiver grass, cotton wool, newspaper (if scrambled and not too compressed), old pieces of blankets etc. – the choice is yours. By using local materials, the fireless cooker can be constructed at no cost at all. Don't forget to build a top cover for the lid! Otherwise the heat disappears through the top. If a big plastic carrier bag is available, the pot can first be stowed in the carrier bag and the bag tied above the lid before the pot goes into the fireless cooker.

Cover: It is important to cover that "filling" with a dry, clean cloth so that no loose particles of the insulation materials can enter accidentally the cooking pot hence spoiling the food.

Container: This insulative material has to be fixed in a container to hold the material in place. This 'container' can have different shapes and can be made out of many materials: a hole in the ground (if dry), a carton box, a clay structure or an old basket or rusty bucket etc. The container must be big enough to accommodate the usual pot size plus two layers of insulation material (formula: diameter of the pot + 2 widths of a palm).

There are many possibilities how to construct a fireless cooker. In general, fireless cookers can be mobile assets or a fixed structure as part of the kitchen structure. Some examples are shown on the next page.

<p>1. Mobile fireless cooker for home use</p>	<p>2. Carrier-basket for sales on market</p>
	
<p>3. fireless cooker with clay container</p>	<p>4. Stove and fireless cooker as "twin unit"</p>
	
<p>5. plastic bag used to protect the cloth</p>	<p>6. rusty old metal bucket put to new use</p>
	

Because of the local conditions in Mulanje, the project mainly focused on mobile fireless cookers as most people do not have a kitchen. As insulation material, dried banana leaves are available in abundance and of no other use. The container can be a locally made basket which is no longer fit as a storage facility when the corners are broken. This otherwise disposed item can still suit the requirements as a fireless cooker. On the next two pages, the construction of such a fireless cooker is illustrated step by step with photographs.



9: make the cushion using another cloth



10: fold the leaves to the size of the basket



11: tie the cloth with a knot to make a cushion, no banana leaves should stick out



12: cook soaked beans for 15 minutes only on the fire (beans must be soaked over night)



13: add the cut onions and tomatoes + salt



14: put into the fireless cooker



15: cover with the cushion and leave for 3 hours: the beans will be cooked and ready to serve!



16: cook rice for only 2 minutes on the fire and leave in fireless cooker for 30 minutes and it will be ready



Several benefits can be observed through the use of the fireless cooker:

Benefit 1: saving fuel

The preparation times for food depend on many factors such as outside temperature, heat of the fire, size of the pieces in the pot, variety of the crops, quantities prepared etc. It is therefore not possible to give general information for boiling times and simmering times. In the following table, some examples of experiences collected in Mulanje (Malawi) are compiled as an indication of potentials. The figures are based on food quantities of one family of 5 members.

food	Traditional boiling time on fire	Preparation in fireless cooker		Saving boiling time on fire
		Boiling time on fire	Simmering time in fireless cooker	
Legumes like Beans, Peas etc.	3-4 hours (=240 minutes)	15 minutes	3 hours (= 180 minutes) (if soaked)	225 minutes
(Sweet) potato, cassava, yam, bananas etc.	45 minutes	5 minutes	45 minutes	40 minutes
Green pawpaw	40 minutes	5 minutes	45 minutes	35 minutes
Rice	30 minutes	2 minutes	35 minutes	28 minutes
Chicken, meat	depends	15-20 minutes	2.5 hours	

As a general rough estimation, the boiling time on fire can be reduced to 10% of the traditional boiling time. The simmering time in the fireless cooker should be at least the same time as the total traditional boiling time.

Apart from the fuel saving due to the reduced boiling time, even the initial heating time can be reduced. Cooking in the fireless cooker requires less liquid as evaporation is reduced. Hence less water has to be heated up to the boiling point.

A nice way of demonstrating the insulation properties is to pass the cushion-cover around and ask people to hold it with both hands, placing them flat on either side of the cushion: one hand will feel the hot side of the cushion, that was inside the fireless cooker, the other hand will feel the cool side that was outside. It is still the same cushion people are holding in their hands but the temperature is different. This demonstrates that the heat from the cooking pot was not able to travel through the cushion to escape to the outside, but that it was retained inside the fireless cooker. This is then how the cooking job gets done without additional fire.

Some foods take a long time to cook. Particularly legumes (e.g. beans) have to stay sometimes up to 5 hours on the fire before they are ready for consumption. Many households can no longer afford the cost of firewood these preparations require and stop eating them. As a consequence, a lot of readily available protein at household level is not utilized but sold off.

From a nutrition point of view, this is a very serious problem. Giving up well performing local sources of proteins is a huge set-back on the road to better food security. A retained heat cooker can assist to overcome the shortfalls of the traditional food preparation.

How to cook rice with the fireless cooker:

Measure the rice you want to cook with a cup or any other container. Then measure the water that you need to cook the rice so that it comes out well done to the point. This amount of water can vary a little bit depending on the type of rice you are using, as broken rice will normally absorb more water than a hard-boiling long-grain rice. The amount of water will also depend on how you prepare it before cooking:

If you wash the rice before cooking, then measure 1,5 cups (parts) of water for every cup (part) of rice that you have measured.

If you have clean rice and you don't wash it, then you measure 2 cups (parts) of water for every cup (part) of rice that you have measured.

Make sure that if you have filled the cup up to the brim with rice, you also fill the water up to the same level in the cup.

To find out the suitable amount of water it takes a bit of experimenting. It also depends how you prefer the rice to come out.

Select a cooking pot with a lid that closes well and that fits into your fireless cooker.

Take the quantity of water you measured and bring it to the boil in the way you usually do it (with oil, salt, whatever other spices or condiments you want to add). If you add the rice once it is boiling, you wait until it is starting to boil again and then count 2 minutes (TWO minutes only).

Then remove the cooking pot from the fire and put it into the fireless cooker. If you have, you can use a plastic carrier bag that is big enough to accommodate the cooking pot entirely, this will protect your cloth inside the fireless cooker from the soot of the cooking pot. If you tie the plastic bag over the lid it will prevent vapor to escape from the cooking pot into your insulation material, thus keeping it dry.

Then cover the pot tightly with the cushion-cover of the fireless cooker. Keep checking the outside of the fireless cooker if you feel any heat. If the outside feels a bit warm, it means that the insulation material is too thin in that place and that there is heat escaping from the cooking pot. You will later on have to fix the filling of the insulation material in the areas where the heat was escaping to seal the leak and in future keep the heat inside.

After 30 minutes the rice should be done.

If you are demonstrating this to a group, you can first ask people to come forward and touch the outside of the cushion before you remove it. Ask them what they feel. They will tell you normally that they can't feel any heat. Then take off the cushion and ask people to touch the cooking pot. They will go with the same confidence that they have just touched the cold cushion and touch the hot cooking pot. Normally they will be very surprised to feel the pot being hot.

Take off the lid of the cooking pot for everybody to see how the rice has come up.

Benefit 2: Less wastage of food

Food can not get burned in the fireless cooker as it is off the flames while simmering. Hence, the danger of spoiling food with too much heat is avoided.

Especially with rice, the rice normally does not get burnt, as there is no fire any longer.

Benefit 3: Less labor required for food preparation

When boiling food for several hours, one person must permanently control the fire. This demands a lot of labor which could be used otherwise in the garden, field or other household work if the food would be simmering in the fireless cooker. This is important particularly if labor is a shortage factor (e.g. female headed households).

Benefit 4: Reduced loss of nutrients in the preparation process

Some nutrients get destroyed if they are too long exposed to high temperatures. As the food warms up without flames, the nutrients are less likely to be transformed into less valuable substances.

Cooking temperatures are lower in the fireless cooker so that especially vitamins that are sensitive to heat like Vitamin A and C are preserved better.

Household energy saving technologies	
Module 4:	Retained heat cooker (‘fireless cooker’ or ‘food warmer’)

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The training session is aimed at men and women in the communities: people who do the cooking and people who consume the food. Both should understand the advantages of the technology.

Expected output: “What shall the trainees be able to do?”

- Understand the principles of the fireless cooker and retained heat
- Understand the importance of dry insulation material
- Know the possible applications of the fireless cooker (for which food types)
- Know how to handle the fireless cooker to reduce cooking time on the fire
- Construct a fireless cooker out of locally available suitable materials
- Be aware of advantages and dangers of a fireless cooker/food warmer

Sequence of sessions: “How to achieve the output?”

- Step 1: Cooking ‘competition’ with legumes and rice in traditional and improved way;
- Step 2: Construction of fireless cooker;
- Step 3: Assessment of the two different cooking methods in terms of firewood consumption, taste of food, practicability etc.

Tabular session guides: Session 1 (Cooking competition)

Step 1: Cooking competition

To SEE

Steps	Tools	Group	Materials	Time
Starter	Facilitator is holding 5 sticks of firewood in his hands and asks if participants think that it is possible to prepare a pot full of rice and one pot with vegetables by only using these three sticks using the traditional 3 stone stove.	all	3 sticks dried firewood	5 min.
Self discovery	Cooking competition: a team of participants prepare the same amount of rice and vegetables as the facilitator, but by applying their usual cooking techniques. The trainer uses improved kitchen management and the food wormer. Firewood consumption will be carefully observed and counted.	all	Firewood, rice, water, vegetables (what ever available, e.g. leaf mustard) Food wormer 4 identical cooking posts	40 min.

Step 2: Construction of food wormer

While the cooking competition is going on, the construction of a food wormer can be demonstrated (follow instruction of picture page in factsheet).

Step 3: Assessment of cooking competition

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	How many sticks firewood were used in the different preparations? What is the reason for the difference? How does the food taste – is there a difference between the 2 teams? Enjoy the food!!!	all	Flipchart, marker	1h
Additional aspects from the facilitator	How does the food wormer function? (demonstration of inside-outside temperature difference) What are the benefits of using a food wormer? (firewood, time, no burning, better nutrients – see factsheet) How long can we keep the food worm? (not longer than 6 hours – see factsheet)	all	Flipchart, marker	30 min.

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Can you construct a food wormer for yourself? Can you use the food wormer at your house?	all	-	10 min

Household energy saving technologies	
Module 5:	Chitetezo Mbaula – the “Protecting Stove”

FACTSHEET

Problem: “3-stone-stove is wasteful and dangerous”

In general, households do like their 3-stone stove. This is partially because they don't know any alternative. Being questioned more in detail about their cooking situation, they start to discover that there are some important problems linked to the use of the “mafua” (=3-stone stove).



High firewood consumption:

Households sometimes spent more money on firewood for the preparation of a meal than for the actual food stuff.

High danger for health:

The use of the mafua is dangerous for the cook as well as for kids. People get burned and are exposed to a lot of smoke and ashes. Ember can be blown around starting fires at your house or field.

Not practical in rainy season:

If you cook outside and the rain starts, the fire cannot be moved.

Local/traditional coping strategies or methods: not available

Analysis of the “mafua” (3-stone stove):

Before the start of any intervention into the cooking system, it is important to understand the reasons for the experienced problems with the traditional cooking technologies.

Fire insufficiently sheltered:

The heat can radiate in many directions. The cooking pot absorbs only a smaller percentage of the heat produced. This leads to high fuel consumption. At the same time, this characteristic also promotes the wind to attack the fire resulting in the spreading of ash, ember and flames around the stove. In the process of food preparation, the cook has to lean over the stove in order to check or stir the content of the pot. As the fire is not well sheltered, this can result in clothes catching fire. Because the fire is not confined in a structure, kids can fall accidentally into the flames.

Mafua built from 3 stones:

In the process of “heavy duty” cooking (e.g. nsima), one of the stones may accidentally move. This can result in loss of food and even the burning of skin.

Project Innovations for better protected stove fire

There are many institutions and projects involved in the development of better cooking technologies. The promoted stoves are based on different fuels (firewood, charcoal, coal, ethanol, waste paper bricks, saw dust bricks, paraffin etc.) and made out of different materials (mud, clay, metal, stones etc.). You can find a lively competition of stove “believes” once you start getting involved (see e.g. on the website <http://www.hedon.info>).

It is dangerous to be “carried away” by technical opportunities and considerations. You have to be clear that the imperative factor is the targeting of your intervention:

<p style="text-align: center;">Who is the “target group”?</p> <p style="text-align: center;">How do they prepare their food?</p> <p style="text-align: center;">What are their interests?</p> <p style="text-align: center;">What are their limitations for a “cooking technology” transfer?</p>
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The deduction of the technology decision through the targeting process:

- ⇒ For IFSP, the targeted beneficiaries are several thousands of food insecure households in 185 project villages with a very low purchasing power. The new technology must therefore be very cheap and easily being made available in large numbers. This is best possible if the technology is based on locally available resources and basic production skills which can be elaborated from already existing knowledge. For Mulanje, a clay stove is most appropriate. Clay soil is available in large quantities. Women are already used to produce pottery products such as pots and plates out of clay. It is not difficult to apply these skills to the production of stoves.
- ⇒ Cooking is done mostly outdoors, as many people can not afford to build a kitchen. The stove design does therefore not provide a chimney. On the other hand, the stove should have a floor to make the fire moveable in case of rains.

- ⇒ Cooking is done two to three times a day mostly with one pot only. The stove therefore needs only one flame.
- ⇒ There is no standard pot size in Mulanje. Pots do have very different diameters. They have different shapes (flat and round bottom, but usually wider than tall) and are made out of various materials (enameled metal, aluminum, clay etc.). The stove has to be able to accommodate all those variations.
- ⇒ Villagers complain a lot about smoke. The new stove must reduce the problem.

Please note:

There are more fuel efficient technologies available than clay stoves. But they are based on other construction materials and/or other fuels. This makes them more expensive in terms of procurement as well as the running costs. Because of that, they are not affordable for the majority of the target group of IFSP. It is therefore better to have many thousands of stove users with a smaller fuel reduction than very few stove users with a high efficiency increase. The overall impact is still higher.

A technology transfer requires very knowledgeable trainers. IFSP requested the Intermediate Technology Centre in Kenya to assist in the technology selection and the training of trainers (itkisumu@africaonline.co.ke). They provided training manuals for the extension workers and handouts for the village promoters. Meanwhile, the local extension workers in Mulanje and some of the village promoters are very skillful and experienced in the promotion of improved clay stoves.

This module cannot substitute the use of those trainers or the manuals. But we can give you an overview on the most important aspects of this technology transfer and our experiences so far. This could assist you in the decision if you want to start promoting household energy saving technologies.

The general characteristics of the “Chitetezo Mbaula”



Fuel

The selected stove design is a portable single-pot stove out of fired clay. It is designed to burn wood although it can also burn crop waste such as maize stalks, pigeon pea stalks, maize cobs, animal dung etc. Fuel is fed into the fire through the fire-door in the front.

Smoke

The stove does not have a chimney, but it still produces less smoke than an open fire. That is due to the fact that it burns the fuel more efficiently. Tests done in Kenya have shown that it produces up to 60% less smoke than an open fire as long as the firewood is dry.

Pot-size

It can accommodate one pot at a time. Because of the design of the potrests, the stove can accommodate small, medium and large cooking pots.

Mobility

The stove has got handles on the sides and can be carried even during the cooking process. It has a floor so that the fire can be carried with the stove, unlike with the mafua 3-stone fire.

Material and costs

Locally found pottery clay, which is available at no cost, can be used for the production of the stove. Firing of the stove requires firewood but increases longevity.

Dimensions

The design is based on the ‘Maendeleo stove’ from Kenya, also known as ‘Upesi stove’, the training was done in Mulanje by the consultant Vivienne Abbott in February 2000:

- ⇒ Firebox height 18 – 20 cm (from the wrist to the fingertips)
- ⇒ Flat Potrests, 1.5 cm high, for different pot sizes and shapes (1 finger high)
- ⇒ Door width 12x10 cm up to 15x13 cm (1 width of a palm high)
- ⇒ Diameter = size of the most commonly used pot, usually 20 – 22 cm

It is critical to respect these dimensions, otherwise the stove might lose efficiency. The most important part of the quality control of the stoves is to prevent the ‘design drift’. People should not start decorating the stoves or make holes in it. If the fire doesn’t burn properly otherwise, it is most probably the problem of the use and the type of firewood (too wet, too big, too much etc.), rather than the stove design. This design has proven to be the most appropriate design for simple clay stoves and suitable in thousands of stoves used in Eastern Africa since it was developed in the 1980’s in Kenya.

In order to control the dimensions, you can use the hands for the correct measurements.

You do not need a ruler! All measurements are done with your own hands!

If you are not using a mould and the stove is built free-hand, a good way to measure the height is as follows:

Height of firebox: From the wrist to the finger tips = 18 cm

How to measure it:

- Place the fingertips on the floor of the stove
- Place the index of the other hand just above of the wristbone as shown in the photo. For the majority of people the distance between that bone and their fingertips is about 18 to 20 cm.

If the stove wall has reached the same height, it is high enough. Please remember that clay shrinks about 10 – 20 % when drying. So to get to a firebox height of 18 cm of the fired stove the wet stove should be 20 cm high.



Importance:

If the stove is too low (less than 18 cm), the fire will not have enough space to develop properly and the fire will choke. If the stove is too high, the heat transmission from the fire to the pot will not be optimal and the fire will be wasteful. Remember that the hottest point of a fire is not at the end of the yellow flames, but above the end of the flames. Heat transfer into the pot happens in two ways:

1. one is by convective heat, when the hot gases hit the bottom of the cooking pot and the heat is transferred into the pot by ‘rubbing’ against the pot surface as much as possible. A very high portable stove also becomes instable and can cause accidents when the heavy pot causes the stove to fall over.
2. The other way of heat transfer is by radiant heat from the glowing embers, so the distance from the pot to the embers should not be more than 15 cm (normally the embers are piling up on the stove floor and therefore raised above the stove floor)

The stove height of 18 cm is the compromise between stability, convective and radiant heat optimum.

Width of the stove wall = 2 fingers wide = ca. 3 cm

How to measure it:

- Place the index and the middle finger on the stove wall. The wall should be not more than the two fingers wide.

Importance:

If the wall of the stove body is too thick, the stove will be very heavy and use a lot of clay. It is more likely to burst in the firing process.

If the stove wall is too thin (less than the two fingers wide), then the stove wall might not be able to support a heavy pot and collapse.



Door dimensions 15 cm wide x 12 cm high	
<p>Width of the door = the length of your hand from the wristbone to the knuckles in the middle of your fingers = 15 cm</p> <p>How to measure it:</p> <ul style="list-style-type: none"> • The distance between the wristbone and the knuckles marks the width of the door. • Mark the places with the index of the other hand on the wet clay to give you the outline of the door. 	
<p>Importance:</p> <p>If the door is too wide, it will make the stove body unstable: the part above the door is likely to sink down during drying and deform the stove body. Cracks are likely to form and lead eventually to breakages of the stove above the door. There will not be enough support for the weight of a heavy pot.</p>	
<p>Height of the door = 1 width of a palm high = 10-12 cm</p> <ul style="list-style-type: none"> • Place your hand alongside the outer wall of the stove with the side of the ring finger pointing down and the side of your thumb pointing up. The upper edge of your thumb marks the height of the door (see also photo above). • Then mark the outline of the door with your index, but don't cut the door yet. The clay has to dry out for a day before you should cut the door, otherwise the part above the door is likely to sink down during drying and deform the stove body. 	
<p>Importance:</p> <p>If the door is too small, the fire will not get enough air to burn properly. The fire will develop a lot of smoke.</p> <p>If the door is too big, the draught will be too strong and lead to increased firewood consumption.</p> <p>If the door is too high, the stove wall above the door will become weak. This is the point where a stove is most likely to crack.</p>	
Potrests 1.5 cm higher than the firebox = 1 finger high	

How to measure it:

- ⇒ Place your index fingers of both hands on the upper edge of the firebox. The potrest should be the same height as your fingers. Use both fingers to make sure the potrests are level (having the same height on both sides).

This means that when you put a pot with a flat bottom on the potrests, the gap between the firebox and the pot should be exactly big enough to slide your finger in.



Importance:

If the potrests are too low, the gap between the pot and the firebox is not big enough to let the hot gases out of the firebox. This will lead to a smoky and choking fire. If the potrest are too high, the gap will be too big and the hot gases can escape from the firebox without making proper contact with the pot. This would mean that the heat transfer from the hot gases into the pot will be reduced. The stove will lose further efficiency by producing an increased draught which will make the firewood be consumed quicker.

Distance (Gap) between the pot and the stove body = 1 finger

How to measure it:

- ⇒ Put a pot with a flat bottom on the potrests
- ⇒ Try to fit one finger in the gap between the firebox and the pot. This gap should be exactly big enough to slide your index finger in.
- ⇒ If you use round bottom pots for cooking, e.g. clay pots, then try the same with a round bottom pot. If you can slide more than one finger through, the gap is too big and too much heat will escape the stove without getting into the cooking pot.



Importance:

It is important that the gap between the pot and the stove body is the same in all places, otherwise you create more draught in some places than in others: this might lead to unequal burning of the fire and to burning of the food in the pot on the areas where more hot flue gases hit the pot.

Clay preparation

Construction of the Chitetezo Mbaula clay stove with a mold
(Pictures from IFSP Mulanje)

 <p>1: pound and kneed the clay until it is soft</p>	 <p>Take the stove mould, wet it and apply ashes</p>
 <p>take a quantity of clay and smash it into the stove mould</p>	 <p>start building up the body of the stove spreading the clay equally. Use an horizontally even ground to guarantee that the floor of the stove will be even</p>
 <p>the width of the stove wall should be 2 fingers e.g. ca. 3 cm</p>	 <p>smoothen the walls inside and on the top</p>



get the stove out of the mould



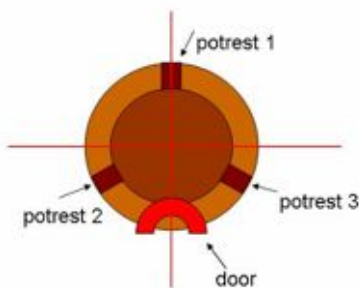
Remove ashes by using a stick or plastic and little water



flatten the top with an inclination sloping inside to help gases escape from the firebox



Take a ruler to find centre of stove. Then draw the door by using the door mould on one side.



On the opposite side of the door should be the first potrest



Use the mould for building the 3 pot rests. Put a plastic for getting the pot rests easily out.



fit the other 2 pot rests in equal distance



fix potrests properly and make sure that they go straight down inside



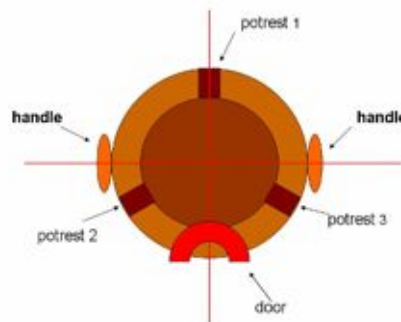
smooth out the pot rests



potrest height should be 1.5 cm (one finger) and flat on the top to prevent pots from wobbling



Potrest width should be 3 fingers



Handles should be in equal distance to the door that should be in the middle



make holes in the wall to fit the handles right through the wall, so they don't break off



Handles must be opposite each other and not too low above floor (one palm width)



Half moon shaped handles are better than round knobs to prevent stove from tipping over



cut the door after one day and fit a knob

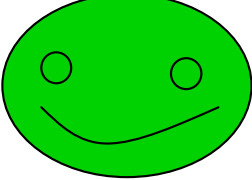



the stove is finished and needs to dry slowly for 2 – 3 weeks covered in a cloth or bag

Before firing the stove don't forget to check the quality criteria

Benefits as perceived by the communities:

The newly introduced clay stove was locally named “Chitetezo mbaula”. The women selected this name to indicate that the stove is protecting the cook from being burned, but also their children. By saving firewood, the stove protects their food security and their natural environment. In village meetings, the following advantages and disadvantages of the new stove were compiled:

 <p>Advantages:</p> <ul style="list-style-type: none">• Made out of locally found pottery clay;• No extra tools needed, everything is locally available;• Easy to make even for unskilled people;• It is cheap, as clay is available at no cost;• It burns Wood that can be collected, bought or even produced by the users;• It also burns other fuel like twigs, leaves, agricultural residues like pigeon pea stalks, maize husks, etc.;• It reduces the firewood consumption;• It saves time: cooking goes faster, and less time is spent on firewood collection;• It is ideal also for elderly or sick people with difficulties to buy or collect firewood.• Firing of the stove requires firewood but increases longevity;• It reduces smoke and therefore health risks. In case of rain, take the fire into the house. The ashes do not fly around and can easily be disposed into the compost pit	 <p>Disadvantages:</p> <ul style="list-style-type: none">• Less light than an open fire• Fuelwood needs to be cut up and implies more work for the cooks (though compensated by less time for firewood purchase or collection).
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Average saving of firewood in comparison to Mafua:

Average saving without advanced kitchen management	App. 40%
Average saving with kitchen and firewood management	App. 60 %
Saving of firewood by using additional fuel	up to 80 %
This figure can be increased by complementing the stove with the ‘fire-less cooker’ / food warmer. No consolidated data on the impact of the food warmer available yet (Jan. 2004).	

The average lifespan of a clay stove is 1-3 years. If it is broken, it can still be installed as a “liner” in a mudstove (see module 6).

Economy:

<p>In Mulanje firewood is normally sold in sticks (see photo). 1 Stick of firewood normally costs 1-2 MK or more.</p> <p>In Thuchila trading centre (shown in the photo) and other makret places in Mulanje district 3 sticks of firewood were selling at 5 MK, this equals to 1.6 MK per stick.</p> <p>Assuming an average price of 1.5 MK per stick the economy can work out as follows:</p>	
<p>Saving per meal (only 3 sticks instead of 7= saving 4 sticks)= $4 \times 1.5 \text{ MK} = 6 \text{ MK}$</p> <p>Saving per day (with two meals per day) = $2 \times 6 \text{ MK} = 12 \text{ MK}$</p> <p>Saving per month (on the basis of 30 days with two meals per day) = $30 \times 12 \text{ MK} = 360 \text{ MK}$</p> <p>Selling price of Chitetezo Mbaula as per January 2004 = 80 – 100 MK</p> <p>Conclusion: Investment pays back in less than 10 days!</p>	

If the price of the firewood in your area is less, the pay-back period will be slightly longer. Even if the price per stick of firewood would be only 0.5 MK, savings would translate into 120 MK per month and the investment would be paid back in less than a month.

Adoption and impact:

In Mulanje alone there were over 20.000 stoves in use as per February 2002. The benefits were well observed by the target communities. Spontaneously, the stoves developed into a commodity. Some ladies specialized in the production of stove for those who have no access to clay or who don't have time or skill to produce a stove on their own. If people are prepared to spend even some of their little income for a stove, the benefits are well observed.

Household energy saving technologies	
Module 5:	Chitetezo Mbaula – the “Protecting Stove”

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The intervention is targeted at village communities who have understood the importance of firewood saving and already know about improved firewood and kitchen management methods. They are using the traditional 3-stone-stove (mafua) and have expressed interest to reduce their firewood consumption further with an improved technology.

It is important to have both men and women in the meetings. Usually it is the woman managing a stove, whereas men have to procure firewood if local access is not available. Men can also assist in bringing in clay.

Expected output: “What shall the trainees be able to do?”

Trainees have seen the potential savings through the use of a better stove. They can explain the principles that lead to those savings and are able to manage own stoves to reduce their firewood consumption by up to 80%.

They know how to access an improved stove: they know where to buy one and/or they are able to construct a stove under the guidance of a trainer.

Sequence of sessions: “How to achieve the output?”

- | | |
|-----------|--|
| Session 1 | Analysis of the traditional 3-stone-stove: firewood use |
| Session 2 | Analysis of the traditional 3-stone-stove: dangers caused |
| Session 3 | Save firewood with a better designed stove: ‘chitetezo mbaula’ |
| Session 4 | How to construct a ‘chitetezo mbaula’ |

Tabular session guides: Session 1
Analysis of the traditional 3-stone-stove ‘mafua’: firewood use

To SEE

Steps	Tools	Group	Materials	Time
Starter	Experiment: ⇒ Light a fire in a local stove and place a pot with a bit of water on it ⇒ Groups should come forward one after the other. Ask every participant to find out, where they feel the highest temperature (hottest spot) ⇒ give every group a match and a box or a burning stick of wood to repeat the experiment individually. Every participant should pass a finger through the flames and then hold a finger about 3 cm above the tip of the flame	Small groups	Matches, firewood, local stove (3-stones) cooking pot	15 min
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is related to our situation? ⇒ Why is it like that? ⇒ What can we do to improve?	Small groups		20 min
Sharing	Where did we find the hottest spots? (compare the blue flames, yellow flames and embers) How is it related to our cooking habits?	all	Flipchart, marker pen	30 min

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	Where is the cooking pot situated in relation to the hottest part of the fire? The pot sits in the ‘cold’ yellow part of the flames, the hot gases above the tip of the flames escape from the side of the stove far away from the pot, especially with wind What consequences does that have for the energy efficiency? Waste of energy, high wood consumption What would be a solution? Move the pot higher above the fire, Shelter the fire, so that the flames don’t leap out = Need for new stove design	all	3 stone stove, cooking pot	20 min
Additional aspects from the facilitator	What characteristics should the new design have in order to use the firewood more efficiently: Sheltered firebox How does the firewood get in: firebox door How does the air get in: firebox door How does the smoke get out: raised potrests How do we want to use it: Where do we cook? What type of pots are used? What materials can we use to produce a stove?	all	Flipchart paper, marker pen	30 min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Self targeted: those who are interested can learn more about the improved stove	all		min

Tabular session guides: Session 2
Analysis of the traditional 3-stone-stove: dangers

To SEE

Steps	Tools	Group	Materials	Time
Starter	The participants are asked to report all accidents that occurred in their village during cooking on the mafua	All		5 min
Self discovery and sharing	⇒ What type of accidents were reported? ⇒ How did the accidents happen? ⇒ Who suffered an accident? ⇒ What was the damage? ⇒ What can we do to avoid accidents?	All	Flipchart Paper, Marker pen	20 min.

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	Why is the mafua causing danger? Open fire: flames leaping out, especially in wind, clothes catching fire, children falling in, burning embers flying around, stones moving when stirring What would be a solution? Shelter the fire for protection	All	3 stone stove, cooking pot	20 min.

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Self targeted: those who are interested can express their readiness to learn more about the improved stove with a sheltered fire	all	Flipchart paper, marker pen	5 min.

Tabular session guides:

Session 3: Save firewood with a better designed stove: ‘chitetezo mbaula’

To SEE: there are two observation stages during the same role play

Steps	Tools	Group	Materials	Time
Starter	<p>Role play / cooking competition:</p> <p>3 people cook identical dishes with the same quantities in identical cooking pots on 3 different stoves share 10 sticks of firewood to each stove and count publicly measure the ingredients each cook is going to use and display them in public</p> <p>Start lighting the fire in all 3 stoves at the same time: Cook A cooks on the traditional 3-stone-stove Cook B uses the chitetezo mbaula but does NOT manage it properly (too much wood, no lid on the pot, fire started before the pot is ready, etc.) Cook C uses the chitetezo mbaula with proper kitchen and firewood management (split sticks of firewood smaller, start with 3 sticks only, use a lid on the pot, use less water to cook the relish etc, see module firewood and kitchen management) During the cooking let the participants observe the way the fire burns in each of the stoves. When a cook has finished cooking a meal, put the fire out and count the remaining sticks of firewood of the stove. Assess the firewood consumption of each stove and analyse the cooking process for each stove..</p>	All	Mafua, 2 chitetezo mbaulas, 3 identical cooking pots with lids, 30 sticks firewood, enough ingredients to cook 3 portions of a most common meal (e.g. nsima with relish) on 3 stoves at the same time	60 min
Self discovery Part one	<p>Describe the way the fire burns in each stove:</p> <p>⇒ What do we see? ⇒ What is happening? ⇒ How is it related to our situation? ⇒ Why is it like that? ⇒ What can we do to improve?</p>	Small groups	Flipchart paper, marker pen	20 min.
Sharing	<p>What differences do we observe?</p> <p>Mafua: flames coming out on the side, lot of smoke, Mbaula B: flames coming out, smoke, cooking faster Mbaula C: no or little flames coming out of the stove, little smoke, cooking goes slower</p>	all		30 min.
Self discovery Part two	<p>Observations on cooking process and firewood use:</p> <p>⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like that? ⇒ What can we do to improve?</p>	Small groups	Flipchart paper, Marker pen	20 min.
Sharing	<p>How is the cooking done in our village? Do we normally manage firewood during cooking? Which stove reflects best the usual habits?</p>	all		20 min.

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	<p>What are the firewood savings by using the mbaula ⇒ Without management (hardware only) ⇒ With proper management</p> <p>Can we afford to keep on cooking on the mafua?</p> <p>What are the advantages of the mafua? What are the advantages of the mbaula? Would the mbaula be an acceptable and suitable alternative to the mafua? How is the risk of catching fire perceived? Why would the mbaula be given the name ‘chitetezo’ (protecting) stove? What is it protecting? Users, less risk to catch fire, less smoke?, household economy What is the role of the design and dimensions to realize the savings of firewood? Pot sees the fire, potrest just high enough to let smoke out but low enough to force hot gases against the pot, optimal heat transfer for pot being close enough to embers,</p>	all	mbaula	45 min
Additional aspects from the facilitator	<p>What economic benefits would the use of the mbaula bring in terms of time for collection or money saved for firewood (work out savings per meal/per day/ per month based on number of sticks saved x price of 1 stick), compare to selling price of a mbaula if commercially available How long would the payback period of the investment be? What would the use of the mbaula mean for our environment? Do we have suitable clay in our area to make mbaulas?</p>	all		15 min.

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	<p>Agree on a date and timing to do a stove construction session for interested people: arrange for clay collection (everybody to bring their own clay), clay preparation and stove construction Pr0moter to explain what ‘tools’ to bring: knife, something to smoothen (maize cob, mango pip, or similar), mortar, old polyethylene maize bag</p>	all		10 min.

Tabular session guides:

Session 4 How to construct a ‘chitetezo mbaula’

Participants should bring their own clay to the session. If people don’t know how and where to get clay, the stove promoter can offer to go together with them to the collection place (quarry).

To SEE

Steps	Tools	Group	Materials	Time
Starter	A stove promoter constructs a stove in front of the group and asks one participant to copy what he/she is doing	all	Clay Something to smoothen	40 min
Self discovery	⇒ What did we see? ⇒ What happened? ⇒ How is it related to our situation? ⇒ Why is it like that? ⇒ What can we do to improve?	all		20 min.
Sharing	For a skilled person it takes not much time to construct a mbaula Even a first timer is able to construct a stove if shown how to do it	all		10 min.

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	What are the difficulties faced by the first-timer? Are we able to do it ourselves? What are the critical dimensions of the stove and why? Where to pay attention: Height of stove body, height of potrests, diameter of stove floor= pot size, make of handles, Later on: location of door (between tow potrests), size of door (not too big, not too small)	all		15 min.

To ACT:

Prepare the clay according to the instructions
 Construct the stoves according to the instructions

Household energy saving technologies	
Module 6:	Fixed stove

FACTSHEET

Problem: “no clay available for chitetezo mbaula construction”

In some areas in Mulanje it is difficult to find clay. Farmers therefore do not manage to adopt the improved stove technology.

Local/traditional coping strategies or methods:

Due to the observed benefits and the fast recovery of the investment, farmers spontaneously started to access the stoves through commercial channels.

Analysis of local/traditional coping strategies or methods:

There is nothing wrong with a commercial structure for the supply of stoves to areas which do not have access to clay soil. But even though the pay back time of the investment is short, the actual cash requirement might still scare away the most vulnerable households.

Project Innovations for alternative improved stoves

The chitetezo mbaula needs to be fired in order to be strong enough. Otherwise it will brake rather soon. But if the clay is mixed with too much sand, the stove can not be fired.



The alternative is a permanently fixed firewood stove, built out of sandy clay soil and stones. The fire-box dimensions and the characteristics are similar to the Chitetezo Mbaula. Therefore, similar savings of firewood can be achieved.

How to build a fixed mudstove

Material for a double stove

4 wheel barrows of any type of Clay (Ant- Hill soil, Building soil or Murram)

4 Cans of water

enough bricks to lay the foundation

Equipment

- Flat board for compacting or use hands
- Hoe for mixing the soil

Mixing process

Mix the soil properly with water. Cover the soil with an empty maize bag for at least 3 days to get mature, this helps to avoid the cracking of the stove.

Building process

Site selection:

a stove should always be built in a well ventilated area and positioned against a wall.

Positioning of the stove:

Mark the area for the foundation of the stove by measuring starting from the wall: If you want to install liners, place them two palm widths away from the wall and leave a gap of at least two palms between them. Without liners: put the most commonly used pots at the place where you want to install your stove then measure two hands on all sides and mark the area.

How to measure it:

The firebox should be surrounded by mud about two palms wide. So to measure the foundations of the stove: take the diameter of the most commonly used pot and add two palm-widths on either side or the total width of the foundation is potsize + 4 palms.

Importance:

If the material is not wide enough, it means that the walls are not strong enough. The mud also acts as insulation material to a certain extent.



Lay the foundation:

Cover the marked area with one layer of bricks.
Check the area again by putting the liners or the pots on top of the bricks and control the distances to the wall. Confirm that the area covered with the bricks is big enough.



Place the liners or the pots on the bricks and start building up the stove body with the matured soil. The mixture should not be too watery but rather loose and crumbly.

Compact the mixture with the flat hand and make sure the mixture is well condensed around the liners.

If you don't use liners, leave the pots in place and build tightly around the pots.



The soil should be built up layer by layer until it reaches the top edge of the liner.

In case you don't use a liner, the stove body must be 18 cm high:
Twist the pot moving up until the holes formed in the mud is 18 cm deep (how measure 18 cm refer to module portable stove).



Leave an opening about one handlength wide for the firebox door. Shape the rest of the stove body accordingly.
If you don't use liners, leave the pots inside until the following day to shape the firebox.
On the following day remove the pots slowly by pulling them out with twisting movements.
Then cut the door: measure the bridge three fingers from the top of the stoves and mark. Fit a wet knife at the same level as the floor of the stove and cut U shape downwards then smoothen.



Shape and finish the fireboxes.

Potrests:

If you don't use liners (which have potrests already):
To fit the pot-rests, follow the instructions on the module for portable stoves. Make sure the potrest are not above the door but just on either side of it.

In the photo a food-warmer or fireless cooker is being added to the stoves on the right hand side.



Critical Dimensions of the MUD STOVE




- Stove height 18 cm
- Size of the door 12-15-cm curved
- Diameter depending on size of pot most commonly used by the family
- Height of the pot rest 1.5 cm above

(explanation of the importance of these measurements see module on portable stoves).

Some user guidance:

- Do not throw water on the stove as it may cause cracks.
- Don't use it with charcoal as it will not burn very efficiently. Charcoal needs a different design and needs airholes underneath the charcoal

Benefit through project interventions, experiences and impact:

	<p>It can accommodate all sizes of pots – even bigger ones for bigger families. That's also good for beer brewing or for larger quantities of nsima. Because it is 'build in', the stove and the pot can not fall.</p>
	<p>You can 'recycle' a broken chitetezo mbaula instead of throwing it away.</p>
	<p>Inside a kitchen it can be well combined with a food warmer as a "twin-stove": Next to the fixed stove a hole is made big enough to accommodate the pot and a layer of insulation material about 1 palm wide on each side (e.g. dry banana leaves). For more details on how to make a food-warmer: refer to module on food warmer.</p>

Household energy saving technologies	
Module 6:	Fixed stove

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The intervention is targeted at men and women in village communities who have seen the advantages of the portable ‘Chitetezo Mbaula’, a fired clay stove, but who are looking for an alternative stove which offers similar qualities and firewood savings. This might be for a number of reasons: lack of suitable clay, the need to cook with very big pots, wanting to cook inside a kitchen, or simply personal choice and preference.

Expected output: “What shall the trainees be able to do?”

Trainees know the applications of a fixed stove as alternative to the portable Chitetezo Mbaula and can explain the advantages of the technology.

They know how to equip their household with a fixed mudstove: they know who can build one for them and/or they are able to construct a stove under the guidance of a trainer.

Sequence of sessions: “How to achieve the output?”

Session 1 Analysis of the Chitetezo Mbaula: what are the limitations?
Session 2 How to construct a ‘chitetezo mbaula’

Tabular session guides: Session 1

Analysis of the Chitetezo Mbaula: What are the constraints?

To SEE

Steps	Tools	Group	Materials	Time
Starter	<p>Experiment 1:</p> <p>⇒ Put a very big pot filled with a least 20 l of water (like for brewing beer) on a chitetezo mbaula and ask a participant to stir the content</p> <p>Experiment 2</p> <p>⇒ Take some anthill soil and mix it with a bit of sand to form a crumbly mixture (the material should not be plastic enough to be moulded)</p> <p>⇒ Ask a participant to make a roll of this material like when moulding a stove</p>	all	<p>Very big pot (drum) Mbaula</p> <p>Anthill soil sand</p>	min
Self discovery	<p>⇒ What did we see?</p> <p>⇒ What happened?</p> <p>⇒ How is related to our situation?</p> <p>⇒ Why is it like that?</p> <p>⇒ What can we do to improve?</p>	small groups		min
Sharing	<p>How is the situation in our village: Do we experience instability when using bigger pots?</p> <p>Is our clay suitable for making mbaulas?</p> <p>Have we experienced problems constructing or firing mbaulas?</p>	all		min

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis	<p>What can we do to improve the stability of the mbaula?</p> <p>Built-in, fixed on the sides</p> <p>What can we do when the clay is not suitable to construct a mbaula?</p> <p>Use a mud structure that does not need to be fired and can be maintained by the users,</p> <p>What needs to be observed?</p> <p>Protection from rain, ventilation for smoke removal to reduce indoor air pollution if built inside a kitchen</p>			min
Additional aspects from the facilitator	<p>Can we have more than one pot on the same fire?</p> <p>Can we integrated a fireless cooker?</p> <p>How of recycle a broken mbaula by fixing it in mud</p>			min

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	<p>Self targeted: those who are interested can learn more about the fixed mud stove.</p> <p>Agree with the promoter on a place where to construct the first stove: if it is a private house, the owner of the house has to look for the materials needed.</p> <p>If the group decides to construct a stove at a public institution like a school they have to agree who brings which material.</p> <p>For materials needed see instructions.</p> <p>Set a date and time for the construction.</p> <p>The group size should not exceed 10 people, otherwise it might be too crowded to work in a confined space.</p>	all		min

Tabular session guides: Session 2 **Construction of a fixed stove**

There are several aspects to be discussed and reflected **on site** before starting the construction. The participants should be involved in the discussion and the decision making process with the promoter asking leading questions:

Site selection for construction:

Is the location chosen protected from rain? What can be done if not?

Ventilation if built inside a kitchen: where are the openings in the wall (doors / windows) through which the smoke can be extracted? Where is the best place to put the stove?

Discuss the importance of the location of a fixed stove in relation to the ventilation possibilities: always create enough draft, opposing slots in the wall are best. If there are no windows in the kitchen, what is the reason? What can be done? Does the kitchen need to be rat-proof?

Design of stove and kitchen:

Do we want to build a stove for one or two pots? Outline the importance of one fire per pot.

What other features could we do when constructing the stove? Inbuilt food warmer

What importance does it have for us to cook on the floor? Is it tradition or are there other good reasons for it? Are we comfortable with it? Could we otherwise make a kitchen that is more comfortable (raising the stove above ground, include

What else do we want from the kitchen? Storage space for firewood, food, inbuilt shelves,...

Construction: Follow the steps as shown in the manual and picture pages.

After finishing the construction, discuss the maintenance tasks and how best to look after a fixed mud-stove.

If you build a stove in a public place e.g. the village school to be used for school feeding, agree on how the maintenance of the stove is going to be organised.

Household energy saving technologies	
Module 7:	Kiln

FACTSHEET

Problem: “high losses when firing stoves”

Stove production has picked up considerably in the IFSP impact area. Some ladies have developed particular good skills and started to produce stoves for the local market. They observe that their business is suffering from high losses in the firing process. A breakage rate of up to 30-50% can be observed. Additionally, the traditional firing is very expensive as you need a lot of firewood.

Local/traditional coping strategies or methods:

No local coping practices were observed.

Analysis of the traditional firing methods:

Why do these negative effects of traditional stove firing occur?

- **High loss rate:** In the traditional “open fire” process, the air dried clay stoves experience a high temperature stress. In a very short time, they are heated to high temperatures. The cooling process is again very rapid. Hence, the material develops cracks which will eventually lead to the breaking of the stove.
- **High firewood consumption:** A lot of heat of the open fire is not utilized for the firing of the stoves. It radiates directly into the sky with no utilization. Because of this, the traditional firing process is very wasteful and costly.

Project Innovation for better drying firing of clay stoves

There are many different models of kilns available for the improved firing of stoves. You can get a good and up-to-date overview on the following web-site (www.hedon.info).

IFSP was supported by one of the most qualified centers for rural technologies: Intermediate Technology Kenya, P.O.Box 39493 Nairobi, Kenya. (email: itkisumu@africaonline.co.ke). They recommended the “Better Bonfire Kiln” as the most adequate model for the situation in Mulanje.



Kiln in Kambenje village

For the training on the construction of the kiln, it is advisable to get assistance of an experienced trainer of kiln user. There are comprehensive manuals available as well. This module can not substitute the above mentioned aids, but we can give you an overview of the construction and firing process. Based on this information you might make a better informed decision on venturing into the kiln business.

Construction of a Better Bonfire Kiln:

1. SITE SELECTION

The site should not be in a swampy place.
The site should be at a raised point.
Should not be near homes or houses

2. MEASUREMENTS

The measurements below are for the big better bonfire kiln which measures 150cm in diameter with a standing radius of 110cm.

3. DIGGING THE BASE

With a hoe dig the measured area to 40cm deep.

4. FILLING AND COMPACTING THE BASE

Pour and spread the sand on the base upto 5cm
Lay the polythene bag over the sand layer ensuring overlap of at least 10 cm at the top with the rest of the ground.
Follow with another layer of sand, 5cm thick to protect it from the sharp stones.
Put up a layer o stones ensuring that non goes on top off each other.
Follow this with a layer of murrum ensuring that all the stones are covered
Sprinkle just a little water so that it can hold while being compacted.
Repeat the layer of stones and then finally fill the murrum top of the 50cm hole.
Sprinkle water and continue compact and levelling.

5. LAYING THE FOUNDATION

Measure the inner diameter of the kiln by placing a centre pole and measuring a radius of 75cm all round from the centre pole marking a circle of 150 cm diameter.

6. PREPARING THE BUILDING MORTAR

Prepare by mixing sand, murrum, anthill clay and water in the ratios of 1:2:1 and enough water to mix to make a thick sticky mixture.

7. LAYING THE KILN FOUNDATION

Spread the building mortar 2 cm thick on the foundation outside the 150 diameter circle.
Arrange a layer of bricks on top of the building mortar all round.
Fill in the building mortar in between the bricks all round.

8. LAYING THE FIRST COURSE OF FIREBOX WALLS

To determine how to do this then the direction of wind must be determined. The channels should run from the direction in which the wind starts and goes.
Use small bricks for laying the channels.

The bricks are laid flat

Starting from the centre lay the bricks from end to end forming the firebox wall.
Lay the next firebox walls on both sides leaving 18cm between them and the centre one.
Continue until there are six firebox walls and five firebox channels.
Fill the five spaces between the firebox walls with the building mortar until it levels with the top o the brick. This forms the floor of the kiln.

9. LAYING THE SECOND COURSE OF THE FIREBOX WALL .

Starting from the centre firebox wall, lay the second course of bricks leaving 10cm ventilation gap between each brick and the other.

Position the gaps such that the ventilation gaps are not in line with each other.

Each of the outer walls should have three ventilation gaps.

10. LAYING THE THIRD COURSE OF FIREBOX WALL

Lay the third layer of bricks this time leaving no gaps.

Ensure that this course is levelled and that all joints are well filled with mortar.

11. COMPLETING THE OUTER WALL

Complete the outer wall by laying two courses of shaped bricks to complete the outer walls leaving the three ventilation channels open on each side off the kiln.

12. SUPPORTING THE KILN WITH A REINFORCEMENT ROD.

Prepare the metal frames as shown in appendix 1

Lay the metal frame across the top of the firebox doors.

13. BUILDING THE KILN WALL.

Lay and level a full circle of bricks.

Continue laying and levelling the bricks to form the kiln wall up to the recommended height, 75 cm, from the floor.

Always ensure that only 2 courses are laid per day.

Cut the binding 15-20 cm and after every course, pass from the bottom of each brick, a wire over to the other side and back allowing to protrude outside the wall.

14. WRAPPING THE CHICKEN WIRE.

Wrap the chicken wire around the outside of the kiln wall and ensure that it is securely tied with the protruding lengths of the binding wire.

15. DRYING

Let the kiln dry for three days.

16. PLASTERING THE KILN WALL

Prepare the plastering material by using the best local mixtures for plastering (mudding) the houses.

Do the first layer of plaster to one cm thick.

Finally plaster the top of the last layer off wall bricks.

The kiln is ready and is left to dry for 28 days before testing.

See following picture page for kiln construction:

Pictures of the construction of Kiln:



The main purposes of a kiln is to save firewood in the stove production process and increase the quality of the fired stoves. The kiln walls shelter the fire thus reducing firewood consumption. The fire can be controlled at the ventilation slots and the heating-up phase can be slowed down. This reduces risk of cracking of the stoves in the firing process. The quality of the fired stoves is improved by higher temperatures as compared to the open fire. Depending on the size a kiln can fire 50 - 150 stoves at a time.

Use and maintenance of the Better Bonfire Kiln:

1. USE

- **Kiln capacity** - The constructed kiln would only accommodate 120 stoves and 40 KCJ liners at each firing period. If pots are to be fired then the kiln carries 60 big pots and 20 small ones during each firing period.
- **Amount of fuel** - 120 upesi stoves and 40 kcj(kenya ceramic jikos) requires 16 bundles of firewood and a bundle of grass
 - 60 big pots and 20 small pots required half the amount used for firing stoves
- Once the kiln is packed as required, lay a thin layer of grass , 2-5cm thick, then smear the top with a thin layer of mud.
- **Firing** temperature 650 - 700 degrees c. For the first three hours light the channels one by one skipping one each time. This means only three channels are initially lit on the direction from which wind is coming. Once they are well lit at the end of three hours , light the other two. Follow the same procedure on the other side.
- Once the whole kiln is well lit, make holes on the mud dome with either fingers or a stick.
- Steadily feed fuelwood into the channels to maintain the same firing temperature.
- If the wind is strong then the firebox doors should be closed using bricks.
- After eight hours check the bottom layer of stoves by looking through the firebox doors If the stoves are glowing, then the firing process is nearly complete.
- Close all the channels using bricks and mud leaving the kiln to cool for 20- 24 hours.
- At the end of 24 hours ,open the blocked channels and bits off the dome.
- Offload the kiln.

2. MAINTENANCE

After each firing inspect the kiln for

- Any fire-box wall bricks that are beginning to sink.
- Joints which have become loose or fallen out.
- Cracks









Repair any of the above defects immediately.

Re-plaster the kiln regularly.

See following picture pages on use of kiln:

Pictures of the use of Kiln:

<p>Bringing all the stoves to fire to the kiln</p>	<p>Place the first stoves inside on top of the fire chamber</p>
<p>Keep loading more stoves, placing them carefully</p>	<p>It is getting more crowded inside the kiln....</p>
<p>The last stoves have to be placed from the outside</p>	<p>Starting the cover of the dome: place grass bundles..</p>
<p>...that serve as support for the final sealing layer of mud.</p>	<p>Sealing the dome: start smearing mud from the top</p>

<p>Make sure all gaps are closed tightly with mud</p>	<p>Now make small holes that can serve as 'chimneys'</p>
	
<p>Starting the kiln on one firechamber</p>	<p>Full fire in all three chambers</p>
	
<p>Monitoring the fire and reloading the fire chambers</p>	<p>Once the stoves are glowing red, block firechamber</p>
	
<p>Let the kiln cool down for at least 1 day or two, then start breaking the dome carefully with a hammer or a stone. If the temperature is still too high, then let cool down more.</p>	<p>Offload stoves only if they are cold enough to be held with bare hands, otherwise they crack if they cool off too quickly. Take care that the stoves don't fall out of the kiln.</p>
	

Trouble shooting during firing

Experienced potters should be familiar with what causes cracks and how to prevent them. Trial and error will help you understand this causes of cracking and how to remedy the situation. Remember that every clay is different and weather conditions vary. Only through experience will you be able to achieve maximum efficiency from the kiln. Below are some of the common problems and possible solutions.

PROBLEM	POSSIBLE CAUSE	POSSIBLE SOLUTION
The kiln is difficult to light.	Wind in opposite direction of the flames. Wood is not dry enough All fireboxes were lit at the same time. Too little ventilation. Wind in opposite direction of the flame. Wet wood Too little ventilation Too little fuelwood Too little draught especially to the dome top and at the wall or dome joints	Light the fire from the direction of the wind Use dry wood Light the two fireboxes later. Make more holes in the dome. Light the fire in the direction of the wind. Use dry wood Make more holes in the dome to draw out the smoke Use more fuelwood Make more holes in the dome
Flames come out of the firebox door.	Wet wood Firing at too high temperature	Use dry wood Reduce amount of fuel used
Too much smoke in the Fireboxes	Damp stoves	Dry stoves well before firing
Underfiring	Damp kiln	Ensure that the kiln floor is above ground level and is provided with a damp-proof layer Shelter the kiln.
	Clay is not properly prepared	Allow clay to mature for several weeks before use and add sand to the clay
Stoves overfired	Clay is too pure	Add fine sawdust or fine chopped grass.
Stoves crack during firing	Clay is too dense Firing process is too fast	Add fine sawdust or fine chopped grass Reduce stocking rate
Stoves crack during firing	Cold draughts Stoves damaged due to mishandling of wet liners Air holes in liners Fast cooling rate	Close firebox doors during firing. Use boards to carry liners. This must be done with care Wedge clay to remove air bubbles before moulding Seal the cracks and firebox doors
One of the most common reasons for stoves cracking is poor quality control during the production.		
Dome collapsing/cracking	Unstable dome	Make the dome higher
Wall cracking	Thermal expansion in joints and bricks Joints in line Using the kiln before it is dry	Repair the cracks Rearrange the joints After construction, allow the kiln to dry for atleast 28 days
Explosions	Damp liners	Dry liners in the sun before firing.
High fuel consumption	Wet fuelwood Waste as flames flow out of the kiln chamber. Weak joint	Use dry wood Replace and repair the joints
Firebox mortar falling off	Overfiring	Reduce fuelwood Consumption rate
Stoves on the kiln floor are cracking	Firing process too fast Cold draughts	Reduce stocking rate Close firebox doors During firing.

Benefit through project interventions, experiences and impact:

Kiln fired stoves have a much higher quality. The clay is fired much stronger and therefore they are more durable.

The experiences with the first IFSP supported kiln in Mulanje are very promising. So far, there were no breakages of stoves after in the firing process observed and less than 5% of the stoves show cracks. The firewood consumption per stove fired has reduced approximately by 50%.

Household energy saving technologies	
Module 7:	Kiln

EXTENSION GUIDELINE

Target group: “Who shall be trained?”

The kiln is targeted at producer of large quantities of clay stoves (or other clay products). As the kiln construction requires some resources (e.g. labor, bricks etc.), commercial stove producer are the most appropriate target group. Their economic benefit from the kiln is high enough to justify an investment of this nature and extend.

Expected output: “What shall the trainees be able to do?”

The trainees build the kiln together with their trainer. They shall be able to repair the kiln on the bases of the knowledge they have gained in the construction process.

Sequence of sessions: “How to achieve the output?”

This extension guideline is restricted to the first sensitization meeting. After stove producers have agreed to build a kiln, the trainer just follows the steps as outlined in the manual.

Please seek professional advice if you start this activity for the first time.

Session 1 (Sensitization for benefits of stove firing in kiln)

Recommendation: invite a facilitator with experiences in kiln construction and kiln stove firing

To SEE: Problem definition

Steps	Tools	Group	Materials	Time
Starter	Question: What are the main problems in the commercial production of stoves?	all	Flip chart paper, marker pen	10 min
Self discovery	Participants reflect their own stove firing experiences and share with their friends:			
Sharing	⇒ High loss rate (high percentage of stoves braking in the fire) ⇒ High costs of firewood for firing ⇒ Cracks in the stoves after firing			

To SEE: difference between normal fired stove and kiln fired stove

Steps	Tools	Group	Materials	Time
Starter	Observation: A normal fired stove and a kiln fired stove are placed next to each other..	all	Normal fired stove, kiln fired stove Flip chart paper, marker pen	15 min
Self discovery	Participants are asked to come forward and compare the two stoves			
Sharing	Differences in color: ⇒ Normal: darkish, not uniform ⇒ Kiln fired: very red, more uniform, lighter Difference in sound when knocked: ⇒ Normal: dull, muffle ⇒ Kiln fired: bell-like, much clearer sound Difference in quality: ⇒ Normal; many small cracks ⇒ Kiln: no cracks			

To REFLECT

Steps	Tools	Group	Materials	Time
Analysis (part 1)	<p>What is the reason for these differences?</p> <p>⇒ Uniform Color of kiln fired stoves: firing conditions in a kiln is more uniform at all places in the fire;</p> <p>⇒ Bell-like sound of kiln fired stoves: in a kiln, the temperature of the fire is much higher. Therefore the clay is burned much harder and becomes very dense, which provide the metal-like sound.</p> <p>⇒ Less cracks in the kiln fired stoves: the firing process in the kiln is much slower. The rise and fall of the heat takes much more time. The clay has time to expand and shrink (24h in kiln, 2h in normal fire) The fast temperature changes in normal fire lead to breakages.</p>	all	Flip chart paper, marker pen,	30 min
Analysis (part 2)	<p>What does that mean for the problems of stove firing as listed at the beginning of the session?</p> <p>⇒ Low loss rate when firing</p> <p>⇒ Less cracks in stove after firing</p>	all	Flip chart paper, marker pen	5 min
Additional aspects from the facilitator	<p>How is the firewood consumption, if the firing process takes so much longer?</p> <p>Experience has shown, that the use of a kiln reduces the firewood requirements by 50%</p>	all	Picture of kiln	5 min.

To ACT

Steps	Tools	Group	Materials	Time
Action orientation	Participants discuss whether they are interested to learn more about how to construct a kiln and agree on process.	all		15 min