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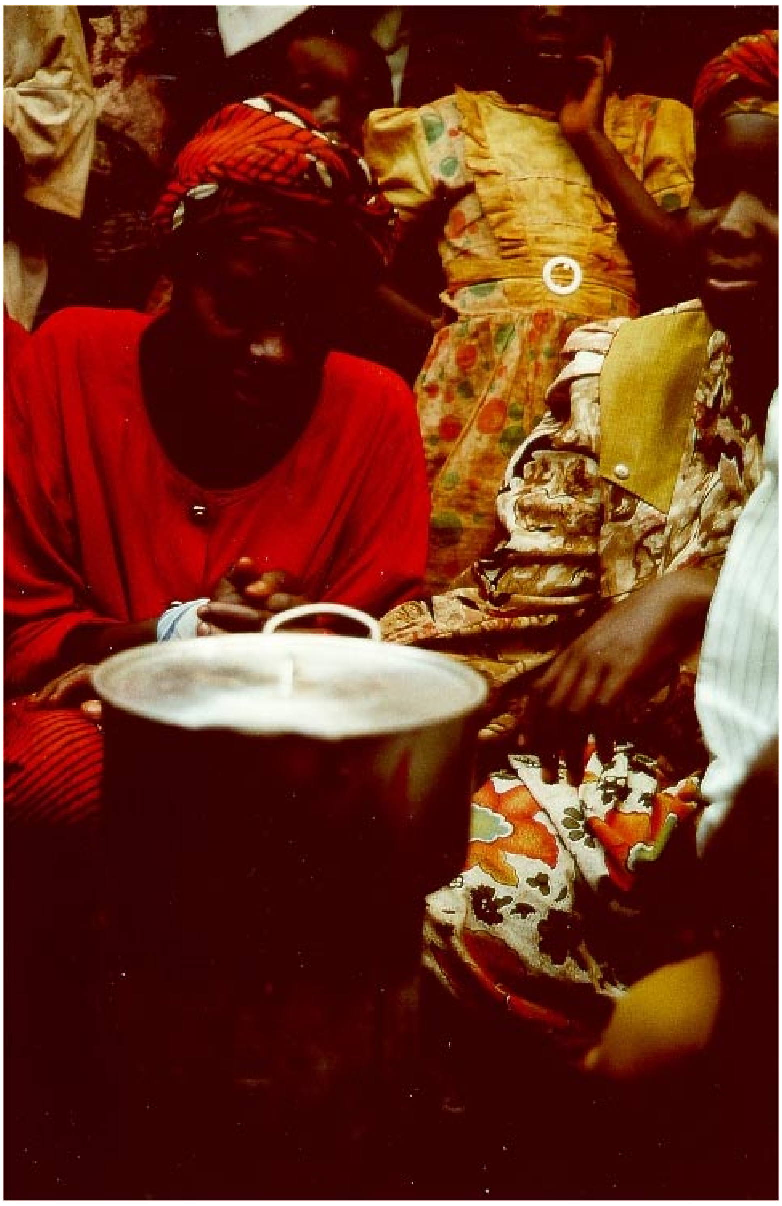
PEKO PE GRASS COOKER
HANDBOOK



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DO YOU HAVE A COOKING FUEL PROBLEM IN YOUR AREA?

DO YOU WANT TO FIGHT DEFORESTATION AND EROSION?

In areas where large populations use mainly firewood for cooking:

- wood gets scarce
- deforestation takes place

This process will be speeded up especially in problematic situations of:

- large refugee camps
- fast growing villages or towns

THE GRASS COOKER COULD BE ONE ALTERNATIVE SOLUTION TO THIS PROBLEM!

BUT WHAT IS A GRASS COOKER?
It is a double cylinder stove, made of clay soil and/or iron sheeting.

WHAT KIND OF FUEL DO YOU NEED TO USE A GRASS COOKER?
Instead of firewood, the stove is fed with a thick stemmed, tall grass type.

WHAT DO YOU NEED TO PRODUCE A GRASS COOKER?
Clay soil and/or corrugated iron sheeting and some basic hand tools.

ARE YOU STILL INTERESTED IN THE GRASS COOKER? THEN READ ON!

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PREFACE

A sufficient fuel (firewood) supply for long term refugee camps and the local population gets more difficult to find. Large areas suffer from deforestation which is often followed by soil erosion. To reduce firewood consumption every possibility has to be taken into account. The firewood used for cooking has to be burned in fuel efficient stoves and alternative energy sources for cooking fuel are needed.

The Peko Pe* stove system can be one solution to this problem !

The Peko Pe metal stove was developed by the Norwegian Engineer Paal Wendelbo and tested on a small scale in 1995-1996 in a refugee camp in Adjumani East Moyo Northern Uganda.

The Swiss Humanitarian Aid Unit (SHA) carried out an enlarged feasibility study on grass cookers and grass as fuel from July 1997 until the end of October 1999. The test was set up in Moyovosi refugee camp and one local Tanzanian village in Kasulu District of Kigoma Region/Tanzania (see map page 4). The project then was handed over to the Kasulu District. The test was divided into two parts:

1. A technical feasibility study on different cookers and grass, considering:

- Material and construction of stoves. (Different thickness of iron sheeting, clay, modification on stove models).
- Preparation of grass as fuel. (Difference between grass species).
- The most economical use of stoves and grass for cooking different food items.

2. An extensive test phase showing the general feasibility of stoves and grass as fuel for large refugee camps and local villages, considering:

- Acceptance of grass as fuel and stove by a large number of refugees.
- Possibilities to use stoves in commune kitchen, e.g. hospitals
- Feasibility of stoves in a long term use
- Protection and harvest of sufficient grass
- Possibilities of grass storage during the rainy season

In October 1999 the ongoing project in Kasulu District was evaluated by an UNHCR consultant team (Matthew Owen, Keith Openshaw, Gacheke Simons). Their results are summarised in the evaluation reports (November 1999). These evaluation reports show the development of the grass cooker project up to October 99 and its possible future extension, but only for the specific situation of the Moyovosi refugee camp and its surrounding Tanzanian villages.

This handbook is a general manual for the production and the proper use of the Peko Pe grass stove. Additionally it gives an overview of the difficulties in introducing a new, unfamiliar technology to a large number of people, who live in a quite desolate environment. Some specific results of the test in Moyovosi refugee camp are highlighted in grey boxes throughout the handbook.

* "the problem solver" – Sudanese dialect-word

Acknowledgements

I would like to thank UNHCR, the Tanzanian authorities, CARE, KaDP and all the agencies involved in the refugee program in Kigoma Region for their support and co-operation during our working period in Kasulu.

I appreciated the confidence SHA headquarters in Bern and Kigali had in our work and the responsibility and independence given to us to carry out this feasibility study.

Special thanks to my colleagues: Urs Bloesch (concept of feasibility study), Heidi Kellerhals, (project manager), Philippe Glauser (enterprising long term project manager) and to my friend Ursina Scrowther for her great work during the technical test phase.

Wetzikon, May 2000 Rico Caveng

WESTERN TANZANIA

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UNHCR ENVIRONMENTAL DATABASE. APRIL 1997.
ADC WORLD MAP, COPYRIGHT.

1 STOVES

The stove is based on a double cylinder system provided with a special arrangement of air holes on the inner and outer cylinder, which allows a perfect air circulation for an optimal burning process. On top of the inner cylinder sits a ring cover. The stove can be produced in two different models, which are the results of intensive cooking tests with differently modified stoves (see pictures below).

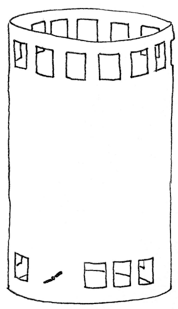
Peko Pe metal stove (the outer cylinder and the combustion chamber plus its ring cover are built from iron sheeting)

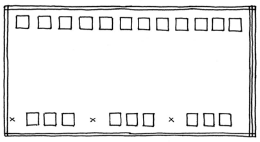
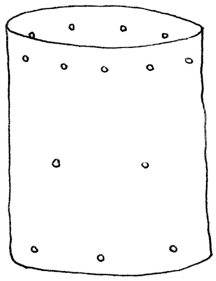
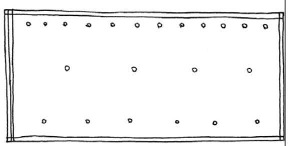
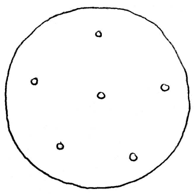
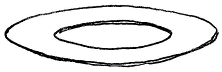
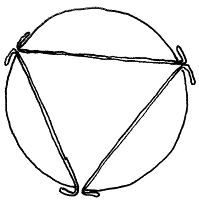
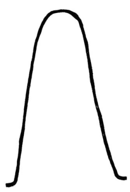
Peko Pe clay-metal stove (the outer cylinder is built from a clay-soil mixture and only the combustion chamber and its ring cover are built from iron sheeting)

1.1 Peko Pe metal stove

1.1.1 Technical specifications

The stoves can be built in different sizes, according to the use they are intended for. For cooking the most appropriate one is a standardised model with the following measurements:

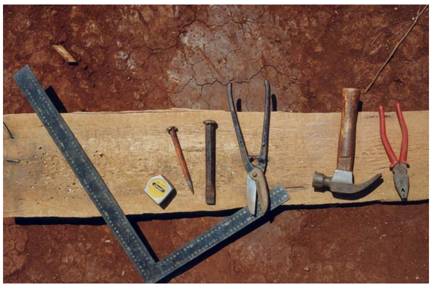
Parts	Measurements	Description
 Outer cylinder	• height: **34.0 cm** • diameter: **20.0 cm**	Arrangement of air holes: • 12 rectangles (height: 3.5 cm; width: 3.0 cm); sitting 1.5-2.0 cm below upper edge. • 9 (3x3) rectangles (height: 3.0 cm; width: 2.5 cm); sitting 3.0-3.5 cm above lower edge • the support for the combustion chamber sits approximately 5.0 cm above lower edge (in the middle of lower rectangles).

	• length: **63 cm** (incl. 3 cm for lock seam) • height: **36 cm** (incl. 2 cm for joins)	
 combustion chamber	• height: **22.5 cm** • diameter: **18.0 cm**	Arrangement of air holes: • 12 holes (diameter: 0.5-1.0 cm); sitting 2.0-2.5 cm below upper edge. • 4 holes (diameter: 0.5-1.0 cm); sitting in the middle of the combustion chamber. • 6 holes (diameter: 0.5-1.0 cm); sitting 0.5-1.0 cm above lower edge.
	• length: **59.5 cm** (incl. 3 cm for lock seam) • height: **24.5 cm** (incl. 2 cm for joins)	
 bottom		• 5-6 holes (diameter: 0.5-1.0 cm); spread evenly across the bottom.
 ring cover	• outer diameter: **19.5-20.0 cm** (tight fit) • inner diameter: **11.5-12.0 cm**	
 combustion chamber supports	• 3 metal-stripes: length: **24-26 cm** width: **3-4 cm**	
 handle for stove	• length of iron rod **60-80 cm**	

1.1.2 Material for construction

To construct the Peko Pe stove, sheeting from iron and mild steel, or galvanised iron sheeting can be used. In third world countries you will always find corrugated iron sheeting. The thicker the sheeting, the longer the stove can be used until it is burnt through. The stove is built by hand with simple hand tools. Therefore the thickness of the sheeting used should be between 0.4-0.8 millimetre. Otherwise it can not be bent and folded properly. Additionally it needs iron rods to produce the handle.

1.1.3 Construction of stove



Tools:

- Tape measure
- Metal shears and pliers
- Chisels
- Hammer (event. additional sledge hammer)
- Punch (round, pointed piece of hard steel), or hand drill
- Piece of rail or logs used as anvils

Procedure of stove construction:

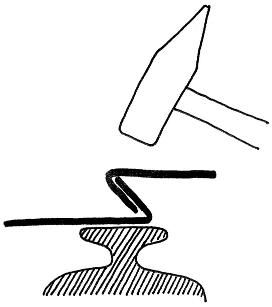
- If corrugated iron sheeting is used it has to be flattened. This can be done by running over it with a car, (attention: sharp stones/rocks on the ground could damage the sheets), or by flattening it with hammer and an anvil (hard work!).

- Draw the outlines of the separate parts on the flat iron sheet.
- Cut the separate parts with metal shears.
- Cut rectangular air holes in the outer cylinder with a chisel.

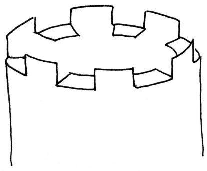
- Punch or drill the round air holes in the combustion chamber (including bottom).
- Punch three holes in the outer cylinder for the support of the combustion chamber.

- Fold in top and bottom edges of the outer cylinder and top edge of the combustion chamber (approximately 1 cm).

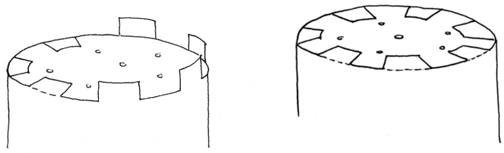
- Join the outer cylinder and the combustion chamber with a lock seam each.



- In bottom edge of combustion chamber cut slots 1 cm deep, 2-3 cm apart.

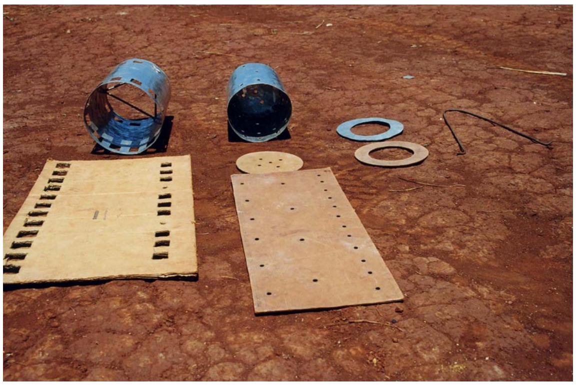


- Insert the bottom, jamming it between the slots.



- Fold the supports into tubes and insert them into the intended holes on the outer cylinder. Fold the ends tightly back.

- Bend the iron rod into a handle (fold thin wire double).



The single parts of the stove can now be put together. The ring cover should sit 1 cm below the upper air holes of the outer cylinder and fit tightly all around.

1.1.4 Cost estimates

The costs to produce 1 Peko Pe metal stove vary due to the type and the amount of iron sheeting locally available. If the metal sheeting is fabricated a long distance away from the place where the stoves are produced, the estimated costs might be increased.

In Northwest Tanzania only galvanised, corrugated iron sheeting of 10 feet (ca. 1 m x 3 m) with thickness gage 28 (ca. 0.4 mm) was used. Iron rods of 12 metres, with a diameter of 6 millimetres were used to produce the handles.

Production:

- Per sheet : 9 cylinders + rings, or 14 combustion chambers + rings can be produced.
- ($ 8.20)
- Per rod: 15 handles can be produced
- ($ 2.30)
- Tools: US$ 15.-
- Per day, one trained tinsmith produces: 5 complete metal stoves, or 10 combustion chambers including rings and handles.

The costs don’t include tools or salaries for staff.

Costs for Peko Pe metal stoves in Kasulu District 1999:

- **1 Peko Pe metal stove from corrugated iron sheeting, gage 28: 2.00 US Dollars.** (Cylinder: $ 0.9; combustion chamber including ring: $ 0.6; handle: $ 0.2; labour: $ 0.3).

- **1 Peko Pe metal stove plus 1 additional combustion chamber: 2.70 US Dollars**.

(Dollar exchange rate Oct. 99: 1.- US$/790.- TSh)

1.1.5 Durability of stove

How long a Peko Pe metal stove will last, depends on different factors:

- thickness of iron sheeting
- frequency of cooking
- handling/maintenance of stove

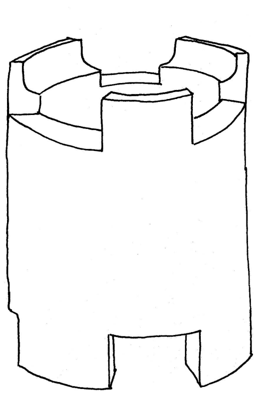
The experience in Moyovosi refugee camp (October 1999) showed, that the **average durability** of the metal stove is at least **2 years.** The majority of people used the Peko Pe in combination with the wood stove. The frequency of usage also depended on the seasonal availability of grass.

1.2 Peko Pe clay-metal stove

1.2.1 Technical specification

It is basically the same stove as the metal one, but the outer cylinder is built from a mixture of clay-soil and hay.

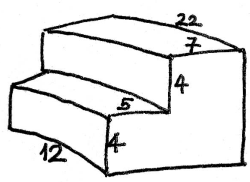
Clay cylinder:

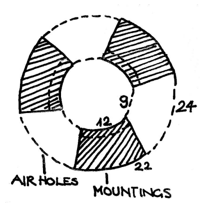


Measurements:

- height: **40 cm**;
- inner diameter: **21 cm**;
- outer diameter: **45 cm**;
- thickn. of wall: **14 cm**

- 3 mountings with step (according to size of pan) and 3 air holes for ventilation. Example of cross-section (diameter of pan ca. 30 cm):





Open bottom

- 3 openings on the bottom (15x15 cm)

Supports of combustion chamber:

- 3 blocks: height: **9 cm**

Combustion chamber and ring cover see Peko Pe metal stove.

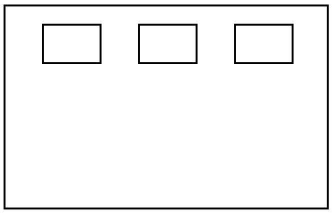
1.2.2 Material to construct a stove

To construct the clay cylinder a mixture of clay-soil and hay is needed. These materials are mostly locally available (e.g. valley bottom) without any expenses. There are differences in the quality of the soil. The higher the content of clay , the better the soil.

1.2.3 Construction of stove

To construct the clay cylinder a tube made from metal sheeting in exactly the right size is necessary (clay shrinks when it dries). Additionally to the tools mentioned for the Peko Pe metal stove, machetes, shovels or hoes are needed.

Pattern for tube:



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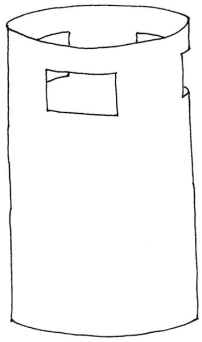
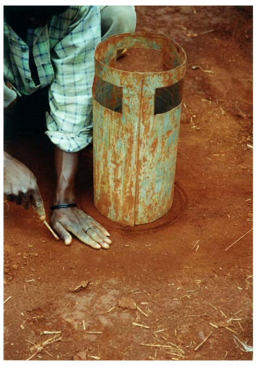


Diameter: **22 cm**

Length: **69 cm**
(3cm incl. for lock seam)
Width: **40 cm**

Procedure of stove construction:

Clay-soil mixture:
1. Mix fine clay-soil and hay (cut in hand wide pieces) in the proportion **3:1**.
2. Add water and work it into a compact dough.
3. Cover with big leaves and grass and leave to rest for 4-6 days.
4. Remix with water to a gluey thick paste.



- Place the tube (pattern) on construction site .
- Then place coil upon coil of mixture on top of each other up to the top end of the tube.
- Leave the intended air holes between the mountings.
- Join the coils by smudging the clay together, in order to achieve a smooth surface.

- Smooth the surface on the outside. Afterwards carefully remove the tube and smooth the inside.

- Pre-cut the mountings to the size of pan mainly used.
- Put in place the supporting blocks for the combustion chamber and mould them to the walls.
- The combustion chamber and its ring cover should sit about 1 cm below the lower edge of the mountings.

- Leave the stove to dry until it is leather-hard. It should stay in the shade or be covered, to avoid cracks by too fast drying.
- Place the combustion chamber and ring inside the clay cylinder. If it sits too tightly, scrape off excess material.
- Complete the mountings (1-2 cm above the ring cover), according to the size of the pan mainly used. (See drawing page 13)

- Cut out the bottom air holes.

- Leave the stove to dry out. To avoid the risk of cracking, the stove has to be completely dry before use. (Approximately 1-2 weeks, depending on weather conditions).

The single parts of the stove can now be put together.

1.2.4 Cost estimates

There are no costs to produce the clay cylinder (apart from costs for trainers, etc.). All materials are locally available. The costs for the combustion chamber depend on the iron sheeting used. (See Peko Pe metal stove).

Costs for Peko Pe clay-metal stove in Kasulu District 1999:

- **1 Peko Pe clay-metal stove: 1.00 US Dollars.** (combustion chamber including ring: $ 0.6; handle: $ 0.2; labour: $ 0.15).

- **1 Peko Pe clay-metal stove plus 1 additional combustion chamber: 1.70 US Dollars.**

The costs don't include tools, or salaries for staff.
(Dollar exchange rate Oct. 99: 1.- US$/790.- TSh)

1.2.5 Durability of clay-metal stove

How long a Peko Pe clay-metal stove will last depends on various factors:
- Proper construction
- Protection from rain
- Handling/maintenance of stove
- Frequency of cooking

The experience in Moyovosi refugee camp (October 1999) shows an **average durability** for the clay-metal stove of **1 year** at least.

Remarks:
The clay cylinder can become cracked by the heat and therefore it has to be repaired from time to time. Repairs with clay soil, or even the replacement of the clay cylinder can easily be done by the owner without any additional costs. (For the durability of the combustion chamber see metal stove).

There is a possibility to construct the combustion chamber from clay as well. It seems that it works, but if it is as efficient and durable as the metal one can not yet be said.
(See Appendix I).

There are various possibilities to modify the clay-metal stove for the cooking of bigger quantities of food. (See Appendix II).

Comparison of the two stove models

	Peko Pe metal stove	Peko Pe clay-metal stove
	In general both stoves have the same good cooking results!	
Mobility	It is portable.	It is not portable.
Size of pans	Different sizes of pans can be used.	The mountings are built to one size of pan. (Some slightly smaller might be used as well
Practical cooking	If food items need to be stirred vigorously, the hot pan has to be removed from the stove and either held in place by hand, or jammed between the feet.	The mountings hold the pan in place. Food items like ugali can be stirred without holding the hot pan.
Safety	The outer metal cylinder gets very hot and therefore there is a higher risk of getting burned.	The clay cylinder doesn't get that hot. Less risk of getting burned.
Stability	There is a certain risk of the stove falling over together with the pan, if pushed hard enough. (Playing children!)	It stays more solidly on the ground and can hardly be pushed over.
Production	One trained tinsmith produces 5 complete metal stoves per day. (Ready for use).	The clay cylinder needs 1-2weeks of drying, before it can be used.
Maintenance	Until the combustion chamber is burnt through there is no special maintenance necessary. To avoid rust it should be sheltered during rainfalls.	The clay cylinder needs some maintenance. It might get cracks, which have to be filled. It also has to be sheltered during rainfalls, otherwise it will fall apart.
Costs	Higher costs for the stove production. Metal sheeting is often not produced locally. The stoves have to be produced by trained tinsmiths. Costs of 1 stove: US$ 2.00	Lower costs for the stove production. Less metal sheeting is used and the clay-soil is locally available for no costs. The user of the stove can participate in the construction of the clay cylinder. Costs of 1 stove: US$ 1.00

Conclusion:

If clay-soil is available the Peko Pe clay-metal stove should be promoted.
The main reasons:
- It can be produced for half the price of the full metal one.
- The user of the clay-metal stove is involved in the production from the beginning.

To facilitate the changing of fuel a second combustion chamber should be supplied, for both types of stove.

2 GRASS AS FUEL

The Peko Pe system is able to burn different materials as fuel:

- Thick stemmed, tall cane grass types, e.g. *Hyperthelia/Hyparrhenia* species; reed, papyrus, etc.
- Rolls of paper and cardboard, etc.
- Leaves, twigs and agricultural waste, etc.

This study is based on an annually regenerating energy source, the thick stemmed *Hyperthelia/Hyparrhenia* species (see pictures below), which grow locally in a large amount in the Kigoma Region in Western Tanzania.

2.1 *Hyperthelia/Hyparrhenia* grass species

The *Hyperthelia/Hyparrhenia** grass species (53 different species are known) grow mainly in eastern tropical Africa and often throughout tropical Africa. The species mainly found in Kigoma Region are: *Hyperthelia dissoluta, Hyparrhenia rufa, Hyparrhenia cymbaria*. It is important to notice that in other tropical regions other tall grass may be appropriate, e.g. *Hyparrhenia diplandra*, *Adropogon gayanus.*

Hyperthelia dissoluta

Hyparrhenia rufa

Hyparrhenia cymbaria

* *Nomenclature:* Troupin G., see references

The grass matures once per year. It starts to dry at the beginning of the dry season around May. Used as fuel, all of the 3 grass types have the same characteristics. The stems, between 1.5 and 4 metres in length, have similar structures. The thickness of the stems varies between 2 and 10 millimetres at ground level. These grasses are typical tussock grasses growing in tufts:

- They are often found in open tree population in grassland, or open savannah.
- They often occur in valley bottoms, or depressions on moderate slopes.
- They prefer areas with a certain ground moisture.
- It seems, that they often occur on land that has been disturbed for shifting cultivation.

Moyovosi and Mtabila lie ecologically in what is known as the *Intermediate Zone* of Kigoma Region, between the less disturbed *Miombo Zone* to the east and the more degraded *Highland Zone* to the west. Average rainfall per year: ~ 1'000 mm. (Owen 1999, see references)

2.2 Availability of grass

One large tract of grassland does not necessarily mean that the whole amount of standing grass can be used as fuel for cooking.

There are different factors which can limit the grass harvest:

- During the dry season bushfires regularly burn large amounts of grassland.
- Access to grassland has to be clarified (privately owned land, or communal land).
- Harvesting and drying period only during the dry season.
- The grass harvested has to be protected from moisture and insects (see grass shelter).
- There is often a high percentage of other vegetation between *Hyperthelia/Hyparrhenia* grass species.

Around Moyovosi refugee camp in Kigoma Region tall cane grasses are growing on several square kilometres:

- Grass per square metre: 0,7-2.5 kg (raw). (SHA evaluation 97).

Calculating on 1-2 grass bundles per square metre, for a full years supply with grass for 20’000 people, an area between 7-14 square kilometres has to be harvested.

However the harvesting was limited, due to:
- Bushfires, without any fire management plan.
- Part of the grassland was privately owned and therefore not accessible.
- Long walking distances, especially at the end of the dry season.

Every environment is different and therefore a study according to the local situation has to be carried out first. Not only a full years supply will be focused on. Even if a large number of refugees could cook with grass during the dry season, it would reduce firewood consumption remarkably.

Example: In 1 month, 1’000 refugees would save 50-60 tons of firewood. (If only grass was used).

2.3 Protection of grassland

The grass matures between April and May and should preferably be harvested when it is only partially dry, from the beginning of the dry season (end of May). The faster the harvest takes place the lower the risk of bushfires. In Northern Tanzania at least 60% of the grassland, or open savannah, burns down annually.

For harvesting areas to be guaranteed during the entire dry season, large grassland has to be protected from bushfires. Therefore a fire management plan has to be worked out. Consultation of an expert is recommended to carry out this plan. If large communities have to be supplied with grass, fire management is urgently required. There are different possible techniques to protect the grassland from bushfires:

1. Fire-breaks: They can be established by controlled burning and should be at least 15 metres wide (assuming that fire-watchers are observing the harvesting areas), respectively 30 metres in the open savannah.

2. Early fires: Surrounding areas of the harvesting plots can be burned early in the dry season (high moisture content of the grass, less heat of the fire), which means that the majority of the woody plants of 1 metre and above remain without damage. This way no firebreaks are necessary.

3. Peripheral cutting of the grass: (see 2.4 Grass harvest).

Some important general remarks:

- A fire management plan should be bound into the locally existing policy of environment protection. (Local population must understand the reason/benefit of the action, because most of the bushfires are lit by local farmers and ranchers.
- A successful realisation of fire-breaks depends on the quality of the organisation.
- An exact field reconnaissance for defining the lay-out of fire-breaks in advance is essential.
- Often fire-breaks can be established by controlled burning, but in other environments the most appropriate fire regime might be different (e.g. no burning at all).
- To avoid an uncontrolled bushfire, fire-breaks have to be realised at the very beginning of the dry season as soon as weather conditions and moisture content of the vegetation allow burning.
- The speed of burning depends on wind, bio-mass, moisture content and humidity.
- Fire-breaks alone are usually not sufficient. The protection can be enhanced by establishing a fire brigade composed of persons of the local community. The patrolling has to be done day and night. (The wages of the fire brigade shall be topped by a bonus, if the protected areas do not burn).



Controlled burning for the realisation of a firebreak (picture 1;2). The final firebreak with a bushfire burning towards it. (picture 3)

The experience in Tanzania shows that bushfires in the early dry season often burn only the finer grass species growing between the tufts of the *Hyperthelia/Hyparrhenia* grass and the leaves and flower buds of the tall grass. The stems (the valuable fuel) remain and can be used as cooking fuel. The faster the low heat fire passes the less damaged the remaining stems are. If the bushfire is violent enough the vegetation can be totally destroyed.

Burnt field

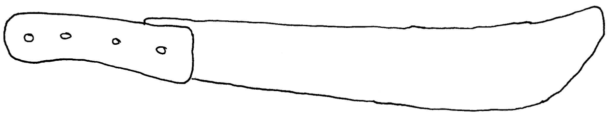
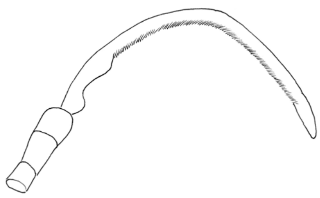
Field with full vegetation

2.4 Grass harvest

Before a harvesting plan can be elaborated, the amount of grass needed for cooking has to be determined. It has to be taken into account that grass is not available all year around.

Generally the grass can be harvested throughout the main dry season (in North Western Tanzania: around Mai-October). Additionally to the regular grass fields the remaining stems on a burnt field can be harvested.

- The grass can be cut with simple hand tools, which are locally available and used: Machetes (mainly used by the refugees in Tanzania) and sickles with a type of saw teeth.

- Harvesting should start at the periphery of the selected grassland. From there the harvesting can be done towards the camp or a village (see pictures page 22). The growing belt of cut grass also reduces the risk of a bushfire entering the not yet harvested area, which certainly has to be guarded (by regularly patrolling fireguards).

- During the dry season, each family cuts their required, weekly amount of grass. This amount of grass can be stored by the families themselves, without building big additional structures for shelters. Some people take the opportunity and harvest extra grass and sell it on the market.

In Moyovosi the raw grass was harvested and transported in bundles of 15 kg each. In October 1999 one bundle of 15 kg was sold at the camp market for TSh 250.-; approx. US$ 0.30, what seems to be a quite reasonable price.

(Exchange rate Oct 99: 1.- US$/790.- TSh)

2.5 Grass shelter

If sufficient grassland is available to supply a large community with grass in the rainy season as well as in the dry season, shelters have to be built, to store the amount of grass needed during the rainy season.

The problems of these grass shelters are basically the following:
- The grass has to be stored on platforms to avoid being eaten by termites and ants.
- Constructions of shelters need an additional budget.
- Shelters need space.
- Storage of a lot of dry grass inside a refugee camp or a village increases the risk of fire.
- In some areas people are not used to store goods for the future (crops grow during all seasons).

Two different types of shelters seem to be possible:

- Every family builds its own shelter. The structures can be simple and might be integrated in the house or compound. For refugee camps some additional poles and plastic sheeting must be distributed.
- Shelters are built for 4-5 families in the centre of their own neighbourhood. The families have to choose the way of storage on their own. Communal harvesting and storage might cause problems of individual claims of ownership.

The selection of the appropriate type of shelter has to be done according to the overall situation of a refugee camp, e.g. building space, culture of refugees, neighbourhood relationships, finances, etc.

Shelter description :
One grass shelter consists of a wooden frame (e.g. eucalyptus poles) covered with plastic sheeting (UNHCR). Two walls are made with grass to prevent the stock of grass from being spoilt by the rain. It is very important, that the plastic sheeted roof is covered with grass or leaves, etc., to be protected from the ultra-violet influence of the sun.

Measurements: 8 m x 4 m x 2 m.

The grass is stored on a platform, 0.5 metres above ground level, to prevent the infestation by termites and to guarantee a good air circulation. Additionally, plants which act as a termite repellent, can be planted around the shelter (e.g. *Euphorbia tirucalli*).

Storage capacity:
The shelter could accommodate up to 5'000 kg of grass, but 4 tons will be a reasonable maximum to guarantee sufficient ventilation. During the dry season the shelter can be filled with 260 bundles of raw grass with an average weight of 15 kg each.

4-5 families need 3'000-5'000 kg of raw grass for a 6 months (approx. period of rainy season) full supply. This amount is within the storage capacity of one shelter.

Tools, Materials and Manpower:
Tape-measure, machetes, hoes, hammers, handsaws, eventually some oil to impregnate poles against termites.

Eucalyptus poles:	80 poles (approx. 600 current metres)
Nails:	8 kg (2’ = 3 kg; 3’ = 2 kg; 4’ = 3 kg)
Plastic sheeting:	2.5 pieces (4 m x 5 m each)
Sisal string:	1 roll

A team of 4 experienced people can build a shelter within 2 to 3 days.

Cost estimations depend on:
- availability of material
- transport
- manpower

Maintenance:
A grass shelter needs about the same maintenance as every building in this environment. The roof has to be checked frequently and the grass on top might have to be replaced after the rainy season.

Moyovosi refugee camp 1999:

To test the possibilities of grass storage, 43 shelters and half shelters were built in 9 of 11 zones. Between 5-10 families stored grass in one shelter. Only a few stocked sufficient grass for all of the rainy season.
Costs:
1 shelter: 50.- US$, UNHCR delivered the plastic sheeting and transported the poles free of charge. This price includes materials, tools and manpower. (Exchange rate: 1.-US$/790.-TSh)

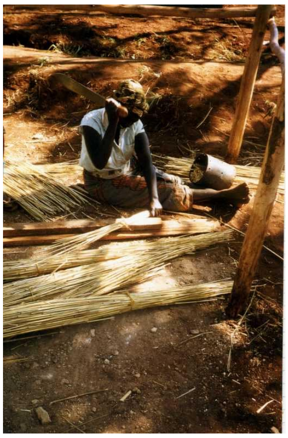
There was no incidents concerning an infestation of termites neither on the Eucalyptus poles, nor on the grass stored in the shelter.

2.6 Making of grass bundles

To use the grass in the Peko Pe stove, it has to be cut and tied into bundles.

Procedure:

- Cut off flower buds and their thin stems and treat them separately. These finer parts are either used for lighting the stove, or, mixed with a few thick stems, made into bundles, to be used for food items with a short cooking time, or to warm up food.



- Hold a few stems in the hand, cut them with the panga in a clean cut to the size of the combustion chamber (slightly shorter than upper edge of the chamber).

- Fill the stems into the combustion chamber in appropriate density. It should easily be possible to put one hand between the grass and the chamber wall. Tie the stems with a string or any plant fibre, e.g. grass, strips of banana leaves, etc. (no tree bark!).

The grass (half dry to standing dry) undergoes a loss of material of between 25-40% by the time it is prepared in bundles to use for cooking. The average weight of a prepared grass bundle is 550 grams.

Moyovosi 1999:

- A family of 5 persons uses about 38 minutes in average to prepare their daily amount of 5 bundles.
- A family of five needs for cooking (full supply) 3-4 kilograms of prepared grass per day (5-8 prepared bundles), respectively 1-2 bundles per person.

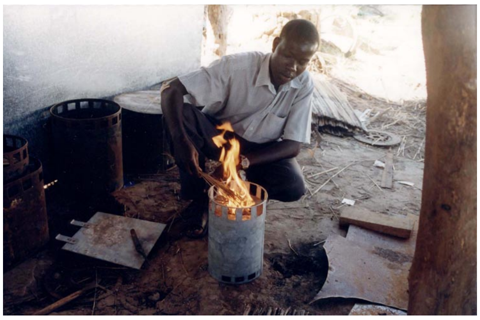
3 USAGE OF THE STOVES FOR COOKING

3.1 Lighting/handling of the stove

- The lower the density of stems, the faster they burn and only low heat remains afterwards. The higher the density of stems, the harder they catch fire and burn.
- In order to get efficient cooking results it is very important, that the flames catch all around the centre of the combustion chamber, before the pan is put on the stove.
- Keep the stove out of windy places! It goes without saying, that during the rainy season the cooking place has to be roofed, especially if the clay-metal stove is used.

The practical preparation of the cooker for cooking:
1. fill the right amount of prepared grass into the combustion chamber.
2. position the combustion chamber into the outer cylinder.
3. place the ring on top.
4. light the grass.

Either you light the grass bundle directly with some burning stems, or you put kindling (flower heads, thin stems, leaves) on top of the grass, then light it and wait until it is burnt. If the fire did not yet catch all around the top of the bundle, some blowing is additionally needed. (If you use the metal stove you can swing the cooker instead of blowing until the grass is lit).



To light the cooker takes less than 5 minutes. If more than 1 bundle of grass is used for cooking, a second combustion chamber is needed. Every changing of fuel needs additional 2-5 minutes, before the pot can go back on the cooker.

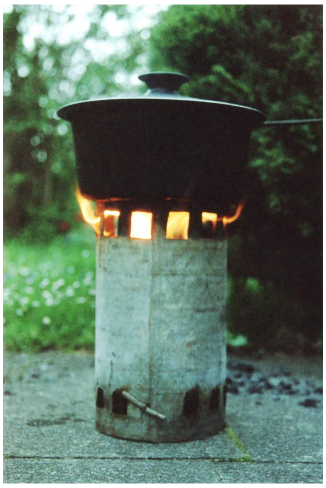
During the lighting phase there is more smoke, than during the burning phase. This is especially noticeable in the rainy season, because the dry grass absorbs moisture.

3.2 Burning time and temperature characteristics

With 400-600 grams of grass, there are flames for approximately 15-30 minutes. The continuous form of the temperature on the bottom of the pan, using an average filling of 550 grams of grass stems is as follows:
The highest temperature, between 500°-600° (up to 700°) Celsius, is reached within 1-2 minutes. The temperature then stays more or less stable for another 10-20 minutes before it drops. This time corresponds to the burning time with flames (first big yellow flames, which

change to blue, similar to gas flames; see pictures below). After 50 minutes, the temperature on the bottom of the pan is still around 200° Celsius, because of the tremendous remaining heat of the glowing mass. This shows that food can continuously be cooked for up to 50 minutes with 1 average grass filling on the Peko Pe stove. Fillings below 400 grams do not have a lot of glowing mass remaining after the grass stems have been burnt. They can only be used to prepare food items with a short cooking time.

Example: 2 litres of water will boil in less than 10 minutes and continue to boil for another 40-50 minutes (up to 60 minutes) using 550 grams of grass stems.



3.3 Practical cooking

- In general all common food items can be cooked the same way, as they are cooked with traditional methods.
- In order to optimise the heat energy, the food items requiring long cooking time shall be cooked first. To warm up pre-cooked food and to cook sauces the remaining heat can be used if possible.
- For food items requiring more than 1 hour of cooking (e.g. beans, etc.), normally more than one grass filling has to be used.
- The weight of the average grass filling of 550 grams can be reduced for very fast-cooking items, e.g. tea, porridge etc.
- The cooking on Peko Pe stoves takes the same time as it does on a wood stove, plus the additional time needed for changing the grass bundles.
- The energy consumption can be minimised by saving measures, e.g. soaking beans, putting a lid on the pan, etc.

Experience of Moyovosi 1997-1999:

- In general the quantity and quality of food one family is able to prepare depends often on the social and economical circumstances. Some live only on the distributed food, or get additional food from local population in exchange for the food distributed. The majority does additional cultivating and some have savings to purchase additional food items on the market.
- Food items like beans, lentils, etc. are cooked in one go. Half of the amount is often eaten with ugali, bananas, etc. for lunch, the other half for dinner, which needs some additional fuel for warming up.

3.4 Fuel Consumption for different food items

During the technical test phase from September until December 1997, all different food items, either distributed by WFP, or locally available on the market, were tested on the two Peko Pe stove models and additionally on improved wood stoves.

Conditions:

- The fuel consumption was minimised as much as possible for both grass and firewood.
- The cooking was done by trained refugee women, closely supervised by the SHA environmental expert and two assistants.

- Our obtained data were compared with the results of the everyday cooking by the refugee women at home and in the test kitchen. (See table below).

The “assumed” amount of grass in the table below, shows the average, which is used in everyday cooking, as a result of this comparison (difference between laboratory results and field practice).

Energy used to cook different food items:

Food items	**average cooking time** °°°	**minimum of grass stems needed**		**“assumed” amount of grass stems for everyday cooking**		**minimum of firewood needed**
		fillings	grams	fillings	grams	grams
1 kg soft beans (dry)	2h 03’	**2**	**1’000**	3	1’650	**1’450**
1 kg soft beans (4 hrs. soaked)	1h 41’	**2**	**1’000**	2	1’100	**1’150**
1 kg hard beans (16 hrs. soaked)	*** 5h 45’	**5**	**2’750**	***	***	**4’500**
1 kg hard beans (17 hrs. soaked) cooked with bicarbonate of soda	3h 27’	**3**	**1’500**	3	1’650	**1’875**
1 kg maize grains (dry)	3h 04’	**3**	**1’650**	4	2’200	**1’700**
1 kg maize grains (crushed)	2h 03’	**2**	**1’000**	2	1’100	**1’425**
1 kg lentils	** 39’/46’	**1**	**350**	1	550	**560**
1 kg maize meal (ugali)	19’	**1**	**400**	1	550	**350**
150gr. csb (porridge)	** 12’/15’	**1**	**200**	1	550	**225**
1 kg bananas	* 22’/17’	**1**	**200**	1	550	**330**
1 kg cassava	* 39’/24’	**1**	**350**	1	550	**525**
1 kg potatoes	35’	**1**	**300**	1	550	**475**
1 kg rice	** 26’/39’	**1**	**350**	1	550	**350**
1 kg cabbage/ 250 gr. dagaa (fish)	* 50’/31’	**1**	**400**	1	550	**400**

°°° This time shows the actual cooking time of the food. When cooking with grass some 5’ have to be added for lighting and changing each filling.

*** The cooking was stopped around this time. According to the refugee women, the hard beans will not change their consistency any more, even if they are cooked for another 3 hours.

** The second, longer cooking time is due to lower heat with fillings of 400 grams and less

* There are soft and hard types of certain vegetables, therefore their cooking time varies.

3.5 Grass consumption for daily needs

The daily consumption of grass varies according to the meals a family cooks per day. The table below shows a selection of possible daily meals, which the refugees prepare. The menus are calculated for a family with 5 members (average family in Moyovosi: 5.3 members/family).

Daily fuel consumption, according to different meals prepared:

Menu	minimum grass consumption	"assumed" grass consumption	minimum firewood consumption	difference to the actual consumption of 5.5 - 10 kg wood/5pers./day
2.5 l tea/ 300 gr. csb 1'000 gr. lentils 2'500 gr. potatoes **total fuel**	400 gr. 350 gr. 550 gr. **1'300 gr.**	550 gr. 550 gr. 1'100 gr. (*) **2'200 gr.**	500 gr. 560 gr. 800 gr. **1'860 gr.**	**3'640 gr. - 8'140 gr.**
2.5 l tea/ 300 gr. csb 1'500 gr. s. beans 2'000 gr. cassava **total fuel**	400 gr. 1'500 gr. 550 gr. **2'450 gr.**	550 gr. 1'650 gr. 1'100 gr. (*) **3'300 gr.**	500 gr. 2'000 gr. 800 gr. **3'300 gr.**	**2'200 gr. - 6'700 gr.**
1'400 gr. crushed maize 600 gr. s. beans/lentils 125 gr. csb **total fuel**	1'200 gr. 1'000 gr./ 350 gr. 200 gr. **2'400 gr.// 1'750 gr.**	1'650 gr. 1'650 gr./ 550 gr. 550 gr. **3'850 gr.// 2'750 gr.**	1'650 gr. 1'450 gr./ 560 gr. 250 gr. **3'350 gr.// 2'460 gr.**	**2'150 gr. - 6'040 gr.// 3'040 gr. - 7'540 gr.**
2.5 l tea/ 300 gr. csb 1'000 gr. rice 1'000 gr. s. beans 2'000 gr. ugali 1'000 gr.cabbage/dagaa **total fuel**	400 gr. 350 gr. 1'000 gr. 550 gr. 400 gr. **2'700 gr.**	550 gr. 550 gr. 1'650 gr. 1'100 gr. (*) 550 gr. **4'400 gr.**	500 gr. 350 gr. 1'150 gr. 700 gr. 400 gr. **3'100 gr.**	**2'400 gr. - 6'900 gr.**

(*) These food items can be cooked with less fuel (550gr.-700gr.), but a second filling might be used. The amount of fuel therefore includes frying onions, tomatoes; warming up food, or boiling some additional water for tea or washing.

The table above shows:

- The possibility to prepare the daily food with 3-4 kilograms of grass.
- That the actual firewood consumption of the refugees is 2-4 times higher than the minimal amount of wood used in the test kitchen. (1. CARE evaluation 97 // 98: 2kg/pers./day // 1.72kg/pers./day). (2. CARE evaluation 98 // 99: 1.25 kg/pers./day // 1.1kg/pers./day; according to UNHCR evaluation team Nov. 99). The reason for this further drop of firewood consumption seems to lay in the fact, that in 99 about 15-30% of refugees dishes consisted of fresh, locally available food. Fresh food items require a shorter cooking time than the dry food distributed by WFP.
- That the use of an improved wood stove does not automatically reduce firewood consumption (overfilled stove, etc.).

Reasons:

- Once the Peko Pe stove is lit, the energy capacity of one grass filling has to be used up to the full. After the flames go out the food continues to cook. This is accepted by the refugees and they leave the pan on the glowing mass, because they have no possibility to add more fuel while the food is cooking. One average filling will cook food for 40-50 minutes, then the filling has to be changed.

- Using a wood stove more firewood can be added all the time. It seems to be a habit of the people to increase the wood in the stove as soon as the flames go down a bit, even if it is not necessary. Big flames probably give the impression of faster cooking. They also fill the stove with more wood than needed, because they want to be able to do other things in the meantime, and are afraid that the cooking will stop without them noticing.

Moyovosi October 1999:

- 1'400 Burundian families = 7'000 refugees = 25% of the population of Moyovosi, cooked on the grass stove.
- 100 Tanzanian families in the village of Shunga cooked on the grass stove.

The Burundian refugees use the grass stove in combination with the wood stove.

Most of the grass stoves and wood stoves are placed indoors.

The majority of people uses the grass stove to cook most of the food items (fast-cooking food), except for the ones that require more than one grass filling until they are cooked, e.g. dry beans, etc.

Their reasons:

- After filling the stove with some big wood sticks they can leave the place until the food is cooked.
- Wood can easily be added by children if necessary, but they cannot change and light a grass bundle.

Wood is additionally used to warm up the house (especially during the rainy season), for light during the night and for brewing.

Over the period of 1 year the firewood consumption dropped about 33-50% (*), with seasonal fluctuations according to the availability of grass and firewood:

- At the beginning of the dry season, when the grass was nearby, they used more grass than firewood.(For any type of food).

- At the end of the dry season the walking distance to collect grass, or firewood, was about the same. Then they collected more firewood. Some people continued to cut grass at the same time. This grass was kept for the rainy season.

(*) 33% according to UNHCR evaluation team, Nov. 99 // 50% according to SHA project manager, 1999.

3.6 Communal cooking

In East Africa people traditionally cook and eat within their families. This tradition should be maintained, if the environmental situation allows it. There is a lot of resistance to communal cooking. On special occasions the commune kitchen is accepted by the people (e.g. hospital). The use of a combination of grass stoves will not be described further here, because the stoves were only used during a relatively short period in 1998. The cooking was successful, but there was no big interest from the responsible organisation and its staff. Two different types of combination stoves, however are explained in Appendix II.

4 PROCEDURE FOR STOVE DISSEMINATION

Introducing a new technology in third world countries is always difficult. There might be a certain resistance to accept something new, which has no tradition in their culture. However there is a difference between introducing a new technology for a feasibility study on a small scale, and implementing a project with a large dissemination of stoves and the supply with grass for as many people as possible. There the procedure should be speeded up to achieve a significant reduction of the firewood consumption within a useful time frame.

4.1 Principles to follow to introduce grass stoves

1. To gather the interest of the local authorities, of national and international organisations working in the area on environmental issues is important.
2. The awareness of the link between the fuel situation and the environment must be spread amongst the refugees and in the local villages around the camp.
3. The identification of possible partner organisations is important.
4. Women are the key people for cooking issues. The selected women have to be carefully introduced in:

- General understanding of the environmental situation and its influence on themselves.
- Awareness of deforestation and firewood scarcity.
- Advantage of seasonally regenerating fuel (grass) source, etc.
- Training to cook on grass stoves.
- Clear explanation of the introduction procedure and their task in the project.

When they have completed their training, they can be employed as trainers/animators to introduce the stove to their population.

5. Preparation of the stove production:

- Selection and training of tinsmith and clay stove fitter.
- Purchase of material needed.
- Planning of tin-workshop.

6. Preparation of the protection of grass, its harvest and storage:

- Defining of the harvesting area has to be done. Property situations!
- The protection of the grass land and the grass harvest should be bound into the regional environmental policy.
- Harvesting plan.
- Construction of shelters if necessary.

7. Distribution of stoves:

- If clay soil is available, the clay-metal stove should be promoted.
- It will be an advantage to distribute a second combustion chamber, no matter which stove model is used. The stove users should be motivated to cook all items on the grass stove and a second combustion chamber facilitates the replacement of fuel. With a second combustion chamber they might at least be motivated to build a second stove. (different size).

Procedure of Introduction in Tanzania 1997-1999:

The first selection of women for the grass cooker test was done on a voluntary base. The 20 women and 1 man received 1 Peko Pe metal stove each for their private use. Together they cooked one free meal per day in the compound, while they were trained to get familiar with the stove and grass as fuel. These were the only benefits, while they were involved in the technical test phase. On top of that they also had the prospects of getting a job as a stove promoter/animator, if the results of the technical tests justified a second extensive test phase with a larger dissemination of stoves. The experience with the Burundian refugees was positive. People with different culture and educational background might act differently.

The test started with the metal stove, because its standardised model was defined first. Later, when the clay-metal model functioned just as well, only this type was promoted (1999) further: Cheaper, more stable! In the beginning there was a certain resistance towards this change, because the metal stove was considered to be the better one: More metal- shinier- more expensive = better!

In the concept for Tanzania it was foreseen to distribute the stoves in return for grass. This grass should be used for institutional cooking. This set-up caused problems amongst the refugees and slowed down the process.

The procedure changed. They had to harvest a certain amount of grass to show their interest, but they could use it afterwards for their own cooking. They additionally had to participate in a course of training to construct the clay cylinder. This scenario seemed quite successful.

5 ACCEPTANCE OF THE GRASS STOVE

There was no cultural resistance against the Peko Pe stove discovered amongst the Burundian refugees in Moyovosi camp.

Their routine in using the stove changed:

- According to season and availability of grass.
- According to the availability of firewood. People are more interested in using the grass stove when the access to firewood gets more difficult.

It is difficult to say if the acceptance amongst a large population would be as high as it was during the test with 7'000 refugees. But considering these families as an average of the refugee population the grass stoves have a good chance of being accepted by a larger population.

The acceptance, however, will probably always depend on the urgency of needs. It will be more problematic to introduce this technology for environmental prevention.

6 SUMMARY AND RECOMMENDATIONS

1. The Peko Pe metal and clay-metal stoves are both technically faultless stoves. With the grass species described in chapter 2, they work perfectly.
2. The stoves can be produced for a reasonable price, with basic skills and low technology.
3. The materials to produce stoves are found almost everywhere in third world countries.

If firewood is scarce, or not available at all in an environment, but appropriate grassland can be harvested, a project with a large dissemination of Peko Pe stoves can be considered.

4. The concept of such a project should focus as far as possible on a self sufficiency of refugees and local population.
5. The number of people that can be supplied with grass depends on:

   - the needs of the people in view.
   - the extent of the grassland.
   - the financial budget of the organisation in charge.

6. A local organisation working in the environment should be bound into the project from the very beginning. This organisation should be able to take over the project after the first phase of implementation and to maintain and integrate it as much as possible into the local structures. For large refugee camps especially, it would require financial support from outside.

The hand-over will be the most critical point in this operation. Different organisations have different positions. There is a lot of competition amongst organisations working in the environment. A newer, or alternative, energy technology often does not get the necessary support of the others. But a project can only succeed if the organisations involved in environment really co-operate.

Firewood is and will continue to be the traditional fuel for cooking in most areas of the third world. We have to make every effort to reduce firewood consumption and the resulting deforestation in these countries.

Appendix I

How to pot a combustion chamber with clay

- For this pottery **pure clay** has to be used
- It is mixed with fine sand. Proportion: 3 x clay : 1 x sand
- The size of the combustion chamber is about the same as the metal one (clay shrinks during drying and firing process, ca. 5-10%).

1. Pottery process:




Mix sand and clay to a compact dough. Work the mixture on to a wooden board with 2 rims



of ca. 1 cm, on the longer side. Smooth the clay with a stick and wrap it around a metal



combustion chamber. Work together the overlapping clay.


Place the air holes. Cover the raw combustion chamber and leave to dry for five days. (Quick drying = cracks).

2. Baking process:



Build a wooden grid over a hollow (air circulation). Put the dry combustion chambers on the



roast and cover all with a big load of dry grass. Light the grass and wait until it is completely



burnt. Then the combustion chambers will be finished and they are ready to use in the


Peko Pe clay cylinder.

Appendix II

Different types of Peko Pe clay-metal stoves

1. Stove combination for institutional cooking

For large quantities of food, which are cooked in institutional kitchen, e.g. in hospitals, a combination of several grass stoves has to be used. To support the greater weight of the pan a clay casing similar to the standardised one has to be built.

4-stove combination (expensive model!)
This model was used in Moyovosi hospital.

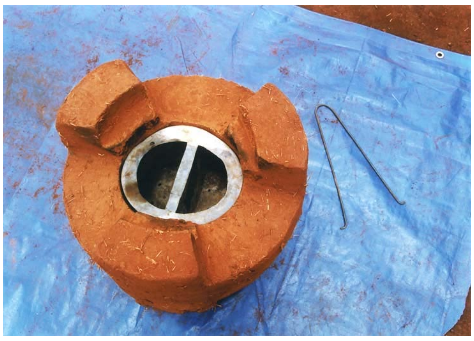


4-stove combination (newer, cheaper model,1999)
This stove seems to work as well as the other one, or even better, because of the one combustion chamber sitting in the centre. The stove had not yet been used on a regular base over a long period.



2. Stove combinations for household

Two-combination stove
This stove can be used for large families.

Variation of stove combination

The picture to the right shows a double clay-metal stove built by a Burundian refugee.

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Drawings by Ursina Scrowther.

Glossary of abbreviations and specialist term:
(unless they are further explained in the text)

Care	International NGO working in the environment.
KaDP	Kasulu Development Programme (Austrian Co-operation)
Miombo	A type of woodland found in much of south-central Africa, at its northern limit in Tanzania. It is dominated by *Brachystegia* and *Julbernadia species.*
Panga	Swahili-word for machete.
Peko Pe	Sudanese dialect-word for " the problem solver"
Ugali	Maize meal cooked with water to a compact dough.
SHA	Swiss Humanitarian Aid Unit; former: Swiss Disaster Relief Unit (SDR)
UNHCR	United Nations High Commissioner for Refugees
WFP	United Nations World Food Programme