Recycling of Organic Waste for Energy and Smallholder Livelihood in The Gambia

Briquette production manual

Basic and advanced technology

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This manual was composed on behalf of The Climate Technology Centre & Network (CTCN). CTCN is the operational arm of the UNFCCC Technology Mechanism, hosted by the UN Environment Programme and the UN Industrial Development Organization (UNIDO).

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Contents

1 Introduction

Experience shows that Solid Waste Management (SWM) is key to maintaining public health in cities and rural areas alike. Turning organic waste matter (bio- waste) into carbonized fuels could be one of the most promising options to stimulate waste collection.

Various processes allow the conversion of bio-waste into energy carriers (i.e. valuable liquids, gases and solids), including biochemical (e.g., anaerobic digestion, enzymatic hydrolysis) and thermochemical (e.g. pyrolysis, torrefaction, gasification, and combustion) methods. The choice of methods depends, inter alia, on the properties of bio-wastes (e.g., type, physiochemical properties and quantity), the desired type of energy carrier, the end use requirements, the health and environmental standards, and the economic conditions as well as project- specific factors.

Sustainable biomass energy has many advantages, as it stems from ubiquitous and affordable resources, creates jobs, ensures diversification and energy security and may be deemed a climate-smart alternative. Moreover, it has been shown that biomass energy is and will remain for decades to come an indispensable energy-source for domestic cooking in sub-Saharan Africa. In this context, the use of non-wood biomass (ground nuts shells, coconut nuts shells, corn cobs, savanna straw, rice husks etc.) is often promoted as a substitute for charcoal, in the form of briquettes. However, despite many advantages (price, length of combustion, environmental sustainability, possibility of standardization ...) these fuels often fail to replace charcoal and firewood. Experience shows that the implementation strategy is specific to each situation and must consider the perspectives of users.

Against this backdrop (and with a view to improving agricultural production, energy supply and livelihood conditions in The Gambia), CTCN has launched a Technical Assistance (TA) entitled "Organic wastes for Energy and Smallholder Livelihood". Said TA's principal outcome was to capacitate women's groups for income generation through waste management, and to improve the waste management value and supply chain at scale. Thereby, short-term local benefits and long-term improvements of governance at local and potentially national levels were to be realized. Direct beneficiaries of the technical assistance were more than 225 women organized in women's groups who have been trained in waste management and charcoal briquette making.

Fact-finding and baseline analyses confirmed that firewood and charcoal are still widely used in The Gambia and, likewise, that resources for briquette production are abundant and available, groundnut shells in particular. Even so, rigorous analysis of the briquette value chain and the evaluation of several possible scenarios for producing and selling them demonstrates that many production strategies are neither viable nor sustainable. Despite this, organising the production chain in two stages makes it possible to propose a profitable value chain model.

On one side of the chain, women's groups produce carbonized material from groundnut shells, mill it before bagging, and sell it to an intermediary (currently WIG) for transport. On the other side of the chain, other women's groups buy bags of carbonized powder (and binder) from the same intermediary. The members of the latter groups turn the carbonized powder into briquettes. It should be noted that the briquettes produced are primarily intended for use by the members who produced them. The sale of briquettes is a secondary aspect.

2 General purpose and objectives of this training manual

The purpose of this manual is to describe the training provided by the TA, so that it can be replicated in other similar contexts, by experienced trainers skilled in charcoal and briquette making. In this case, dedicated trainings adapted to the different groups were organised: Carbonisation and grinding on the one hand, and production and use on the other. It should be noted that special attention is paid to training in the use of briquettes. After a 2-day training dedicated to production, the members of the group are then trained to prepare meals using briquettes as fuel. An additional week's follow-up is then organised. The complete "producer-user" training therefore is 2 weeks long.

This manual presents which steps are necessary to produce briquettes, but it cannot replace the trainer practical experience and skills.

This manual is intended for trainers having experience in briquette production projects and improved carbonization techniques. Trainers should be aware that trainees hail mainly from low incomes households and frequently are illiterate. Training must therefore be based on demonstration and oral discussions.

The first part of the manual (Chapter 3) aims to impart key elements to trainers, including critical preconditions of the effectiveness and sustainability of trainings. A briquette project requires an integrated approach that also considers competition with traditional fuels (firewood and charcoal), marketing, and the management structure. Thus, any briquette project and training require a prior context-analysis to identify logistics and commercial strategies to be adopted and make the fuel competitive. Such ramifications need to

be clarified and duly reflected in the trainings' design and organization.

Experience suggests that any failure to do so can lead to the rejection of briquettes by users. Negative preconceptions also are hard to overcome, even if the briquettes quality later improves. To ensure sustainability and enable success of such projects, the basic rules for the implementation of a "briquette project" are listed, as well as the various items that make up the cost price of a briquette.

The remainder of the manual is meant to assist trainers in implementing the training of briquette production and use.

3 Background and notes

3.1 Briquette-project rules

Trainers should take note of the following general elements that are essential to the success of any briquette project.

- From the user's point of view, no fuel will reach the quality of charcoal! Hence the price of substitutes must be lower than charcoal (for the same cooking work!)
- To meet the charcoal consumers' needs, the produced briquettes must have comparable characteristics, which is why they must contain carbonized material. Briquettes made of non-carbonized material are generally not of good quality and likely to be rejected by users.
- Briquettes are urban fuels.
- Marketing should reach beyond domestic markets, likewise addressing commercial consumers (agribusiness, hotels, tourism operators) or the barbecue niche market.
- Too many projects producing biofuels see themselves as competitors, while in fact they ought to compete against traditional fuels, i.e. firewood and charcoal.

Briquette production projects are regarded as difficult to implement in a sustainable way. The following elements must be considered, in addition to those mentioned hereabove.

- Projects should be designed to be market-driven rather than production-driven.
- Projects must start on a small scale.
- Projects aiming to introduce biofuels as substitutes need to achieve a minimum critical consumption. Large-scale production results in a reduction in production costs only as long as the product is sold in sufficient quantity for the production unit to run at its nominal capacity. Hence, it is preferable to start small, accepting higher production-cost whilst being able to sell all the production. Higher productivity should be aimed for once the market is ready.
- The briquettes produced must be of very good quality and meet consumers' expectations. To this end, raw materials and production processes should be carefully selected and tailored to a given project's needs and scale.

The implementation strategy is specific to each project and must reflect the opinions of users.

Some rules must be considered to implement a financially self-supporting briquette project:

- Good knowledge of the charcoal and firewood market and prices,
- Evaluate the alternative resources regarding quantity and quality,
- Consider all production costs (logistics, mobilization, raw material, transformation, labor, binder, carbonization, briquetting, investment...),
- Consider several scenarios and compare them regarding production costs and competitiveness towards traditional fuels,
- Train consumers in the use briquettes which is dissimilar to that of charcoal,
- Train producers in the use of production equipment,
- Remain mindful that competition is tough and that the odds of a financially viable briquette project are limited.

3.2 Cost structure of briquette production

This section of the manual details the costs to be considered when the briquette selling price is determined. They must be completed according to field realities.

3.2.1 Transport

Transport cost may be the main item in the cost structure if attention is not paid to this necessary production step. This is why it has to be carefully documented: price and capacity of truck (volume) to collect raw material (groundnuts shells) and products (carbonized powder or briquettes), including loading and offloading.

The TA vividly confirmed that transporting carbonized and ground-up material is the cheapest option, preferable to transporting finished briquettes (or non-carbonized raw material). Consequently, briquettes should be produced close to where they are used. Moreover, briquettes are generally not very resistant to transport.

3.2.2 Carbonization

To start the project on a small scale, and to allow production to increase according to demand, the TA favored barrel carbonization. It has the advantage of requiring low investment and being very flexible.

The production of a drum containing carbonized groundnuts shells averaged slightly over 12 kg, while it is 8.2 kg for coconut shells.

3.2.3 Milling

The carbonized material must be ground prior to briquette making. This requires a hammermill driven by either an electrical or a diesel engine. It must be self-ventilating without the need for an additional fan. Diesel-driven mills often are the best option because they operate without the need for grid-access.

3.2.4 The binder

The binder used is starch for ironing clothes, commonly obtained from the purification of cassava roots.

Binder-cost can be influenced in two ways. First, cassava may be replaced with rice starch which, while selling at a different price, is equally suitable as a binder. It has been demonstrated, however that non-food binders do not work for briquettes that can compete with charcoal.

Second, the proportion of binder used may be lowered – with the obvious limit that briquettes to be sold in the market must be of excellent quality. This is the case with a gum proportion of 6.5% by weight of the final product. If rice is used, this proportion will need to be slightly increased to 7.5 %, because its starch content is lower than that of pure cassava-starch. These binder proportions, necessary to promote the acceptability of briquettes at the beginning of the production, can probably be reduced later. The cheapest alternative should be selected.

3.2.5 Pressing

The presses shall ideally be of local construction. Their productivity must be considered in the calculation of the cost-price of briquettes, as well as their purchase-price. This productivity should be estimated for the specific raw materials used in a project. During this TA it was 16 kg/h for carbonized peanut shell powder.

It is very important to set up a chain work to increase press productivity.

3.2.6 Drying

The drying-cost and drying-time have to be assessed. These two factors must be considered when calculating the cost-price.

3.2.7 Wood stoves and fuel use comparison

Boiling water tests have to be carried out to evaluate the equivalence of briquettes and other fuels, i.e. the amount of briquettes, charcoal and firewood needed to carry out an equivalent cooking work. These corrective factors have to be applied when the selling-price of briquettes is compared to other fuels available on the market.

In conclusion, the briquette production scenario must be studied carefully and on a case-by-case basis for the different materials. Indeed, it is possible to produce competitive briquettes but only if the production strategy is well chosen. For instance, during this TA, among the 5 scenarios considered, only scenario 5 allowed the production of a sustainable competitive fuel.

4 Basic technology training

The assessment departed from the production technique applied prior to the TA's start. The equipment used is shown in Pictures 1 to 3: a large biomass burner whose combustion is stopped using water, a pestle and mortar system to reduce the carbonized biomass to powder and a cylinder and hammer system to shape the briquettes.

Picture 1: Basic technology – Biomass burner

Picture 2: Basic technology - piston and hammer briquetting technique

Picture 3: Small scale solution based on current use

Preliminary studies have shown that this technique, owing to its low productivity, does not allow for a viable value chain. The involved women's groups were therefore all equipped with advanced technology equipment.

Training courses for this equipment are similar to those described in Chapter 5.

5 Advanced technology training

5.1 Objective and section content outline

This section explains the detailed operation of the briquette production system and technique developed by the TA.

5.2 Summary of the section

Given the scenario selected for this TA implementation, trainings have to be divided in two main parts: the production of carbonized groundnut shell powder and the production and use of briquettes.

The practical approach is favored, since many trainees will be illiterate. The Manual therefore consists mainly of the list of points to be addressed by trainers during training.

The different topics covered during the training are:

- The production structure and management and the relationship between partners (for both powder producers and users)
- Training for powder production
  - Raw material carbonisation
  - Milling of carbonized material
- Training for briquette production
  - Briquettes making (purchase of carbonized powder, pressing and drying)
  - Cooking food with briquettes
  - Savings highlights

Note: It may happen that only one group is both a producer and a user of carbonized powder. This is the case for some groups producing carbonized powder and wishing to transform it into briquettes.

5.3 Production management

The price structure has to be explained to the trainees. The latter is very dependent on the project-specific conditions and the selected production strategy (or scenarios). The need for the women community to set aside provisions to cover wear and tear costs and operating costs shall be highlighted. A practical solution has to be found within the group and agreed by the members.

At the end of the training the trainees know:

- Who/When/How to call to get grind ground-nut shell powder crushed
- How to manage money inflows and outflows.

5.4 Equipment needed

5.4.1 Barrel

The carbonization drums are made of metal. They have a cylindrical shape, a diameter of 61 cm and a height of 86 cm. The upper surface of the cylinder has a square opening of 30 cm on each side. This opening is closed by a square, flat metal cover 35 cm on each side.

The underside of the barrel can be completely open or drilled with holes with a diameter of 2 cm.

These drums can be made of used oil barrels or manufactured from metal sheets. The construction drawing is presented in Figure 1.

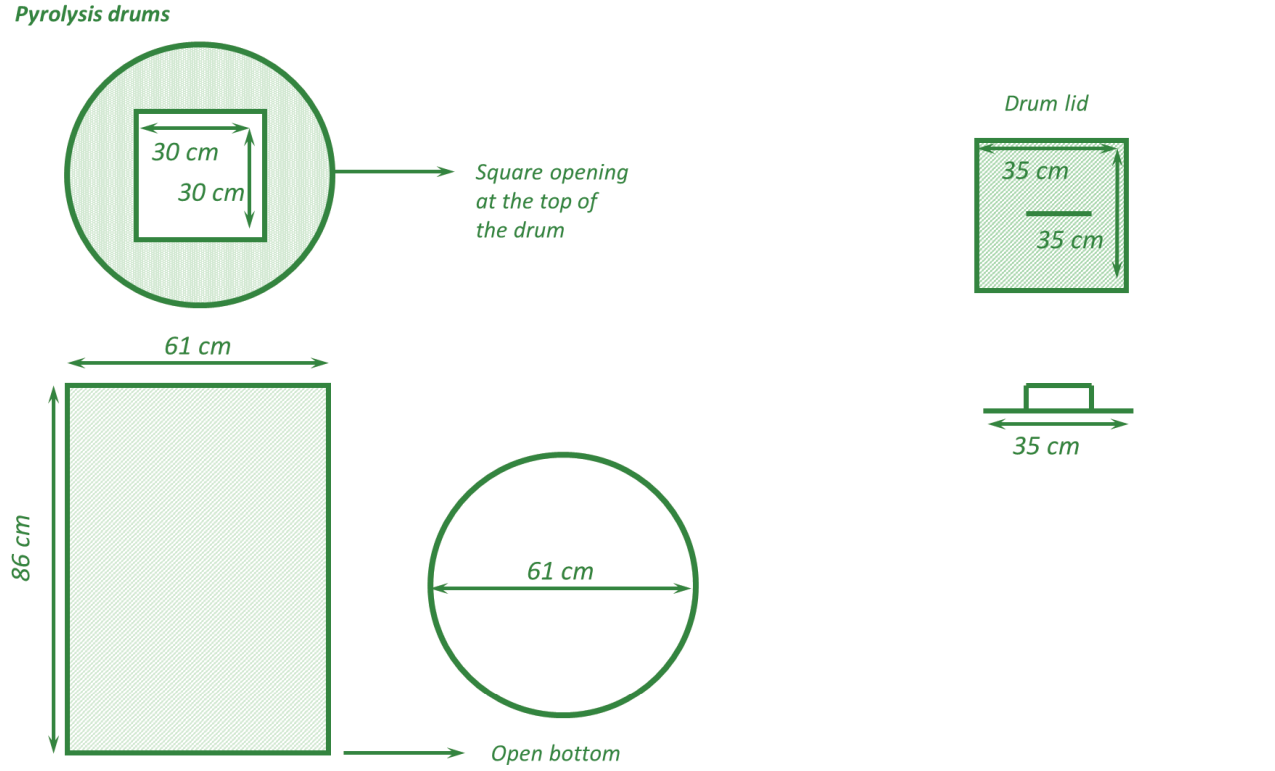

Figure 1: Pyrolysis barrel drawing

5.4.2 Hammermill

The TA used a locally manufactured hammermill (like those used for grinding cereals: rice, maize, mill... – see Picture 4 and Picture 5). The hammermill must ensure the flow of air to evacuate the shredded material by itself (no additional fan is required). It is powered by a diesel engine. In addition, it is equipped with interchangeable sieves, whose meshes measure either 1 or 4 mm in diameter. At delivery, two sets of sieves are supplied with the hammermill.

Picture 4: Hammermill suitable design

Picture 5: Hammermill, milling chamber

5.4.3 Presses

The presses used are manual presses of local construction. The diagram for their construction is shown in Figures 2 and 3. These presses shall be equipped with at least 3 cylindrical briquette moulds. These moulds contain a system for ejecting the briquettes. It is recommended to order 6 moulds when manufacturing the press, in order to have spares. The presses are made of metal and their deck is made of wood, with a hole for placing the rod of the briquette ejection system.

Attention is paid to the fact that the press deck, metal table and drying trays support are of the same height.

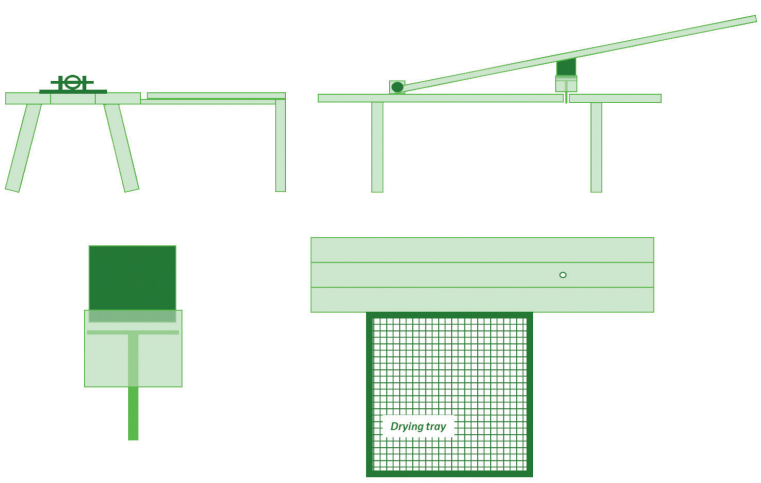

Figure 2: General outline of the different elements required for briquette production

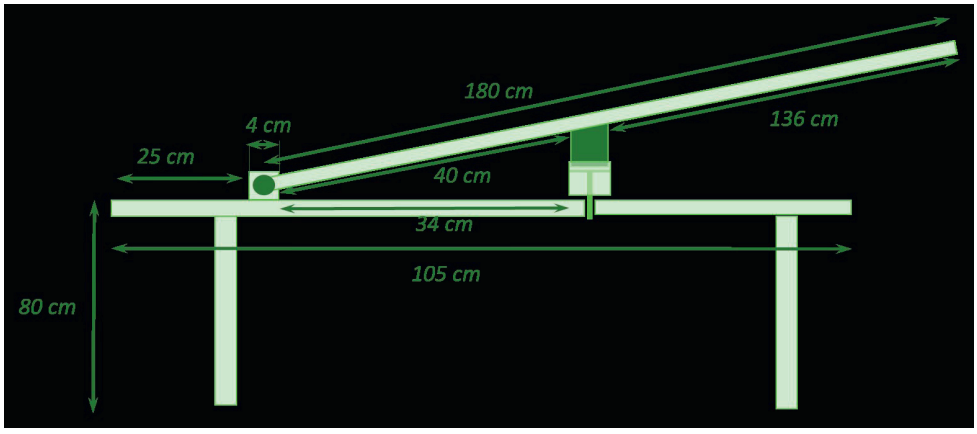

Figure 3: Drawing and dimensions of the briquette presses

5.4.4 Metal tables

A metal table of identical height as the press deck is required to mix the carbonized material and the binder. A diagram is presented in Figure 4.

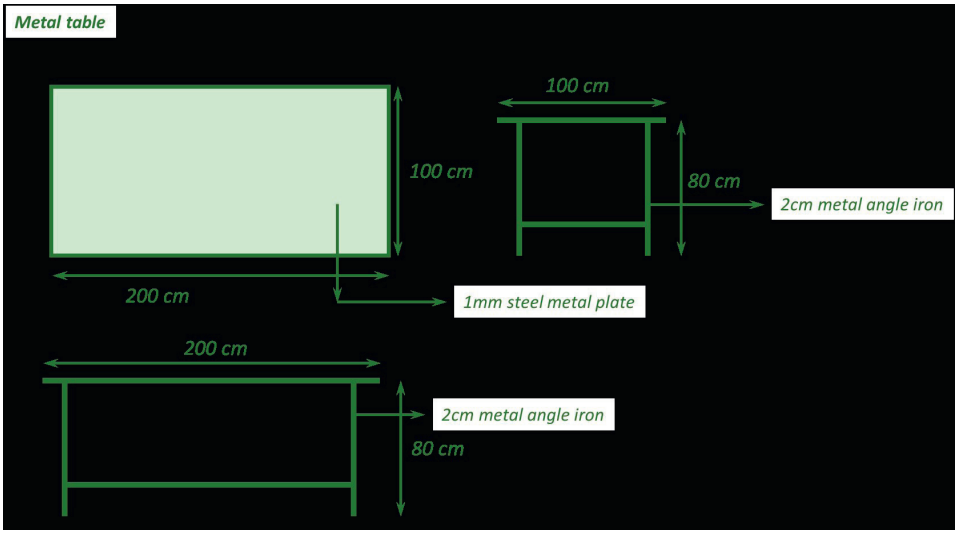

Figure 4: Metal table for powder mixing

5.4.5 Drying trays

The drying trays are square metal frames of 75 cm on each side to which a metal wire mesh is attached. These frames are equipped with 4 stilts 10 cm high, that allow the stacking of the trays even when they are loaded with briquettes.

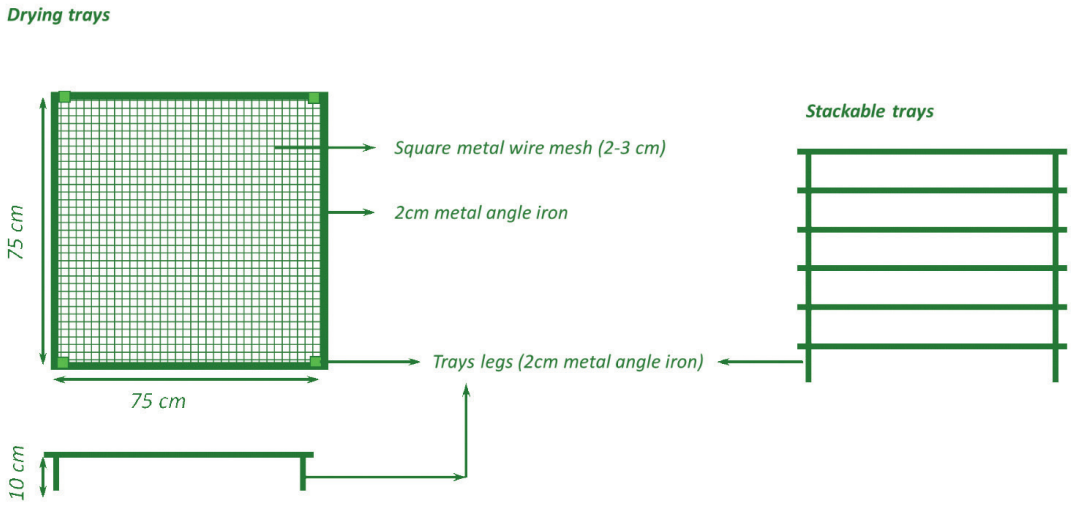

Figure 5: Drawing and dimensions of drying racks

5.4.6 Other items

Other items required for production:

- Bags
- Drying racks
- Tarpaulin (4x6m)
- Gloves
- Masks
- Shovels
- Buckets
- 60 l plastic basin
- Boots
- Coverall
- Wheel barrow
- Improved stoves

5.5 Carbonization training

5.5.1 Safety rules

Before starting, the trainer draws attention to the safety rules to be observed. Carbonization drums contain material at very high temperatures, the walls are hot, it is advisable to avoid breathing the smoke emitted and wear appropriate safety equipment: gloves, mask, overalls. The ground must be cleared before starting to install the drums.

5.5.2 Raw material drying

Depending on the circumstances, raw material may need to be dried prior to carbonization. For instance, coconut shells must dry in the sun for at least 6 weeks before it can be processed.

Corn stalks and peanut shells are generally drier and dry faster, so they can be processed more quickly. The trainer's experience will help to differentiate these moisture content levels.

5.5.3 Prepare the ground around the barrel

Before starting a carbonization, the ground must be cleared and levelled. This in order to allow a plumbing placement of the barrels, which facilitates a homogeneous carbonization. Any combustible material must be removed from the carbonization zone to avoid fires.

5.5.4 How to fill the barrel

The drum is placed on three blocks, or on the ground (with air inlets dug into the ground). The air is necessary for the combustion of the part of the load that will allow carbonization. A stake is placed vertically in the centre of the drum and the material is placed around it and slightly compacted. Once the drum is filled, the stake is removed, leaving a hole in the load from bottom to top.

5.5.5 How to ignite

Straw or another combustible is inserted into the empty space left by the removal of the stake. It is then set on fire.

5.5.6 Differentiate drying and pyrolysis smoke

After ignition, the fire progresses from top to bottom. At first, the smoke emitted is white in colour, this is the drying phase of the material. The smoke then turns thicker and more yellowish at which point it contains enough methane to be ignited. Only the trainer's experience will make it possible to differentiate different stages of combustion by the smoke pattern. White drying phase smoke is shown in Picture 6.

Picture 6: Carbonization process, drying phase

5.5.7 Burn pyrolysis gases

If nothing is done, the pyrolysis gases will burn off spontaneously only after a relatively long time, during which an undetermined but probably significant methane amount will be emitted. It is preferable to accelerate the combustion of methane by placing a lit flare in the smoke, causing it to ignite. The appropriate moment can be judged by the yellowish colour of the smoke, however, this requires experience. As long as the smoke still contains too much water vapour, it will not ignite, but combustible fumes are emitted even before self-ignition.

As soon as the fumes are ignited, no visible emissions from carbonization occur – a factor important to the neighbourhood. Burning fumes are illustrated in Pictures 7 and 8.

Picture 7: Groundnuts carbonization, methane burning

Picture 8: Coco nuts shells carbonization, methane burning

5.5.8 Recognizing complete carbonization

When carbonization is complete, the flames from methane combustion stop and give way to blue-transparent smoke. At that time the volume of the barrel load will have decreased by 50%.

Blue/transparent smoke can also occur when some parts of the load are not completely carbonized. This often happens when the particle-size of material to be carbonized is small (such as groundnut shell for example).

It should be noted that a small amount of non-carbonized residues is not too damaging to the product quality, especially because the product will be mixed during grinding. Carbonized products are illustrated in Pictures 9 and 10.

Picture 9: Partly pyrolyzed groundnut shells

Picture 10: Pyrolyzed coconut shells

5.5.9 Stopping the process before burning the coal produced

Over-carbonization will have a more negative impact on the product than under-carbonization. Indeed, if carbonization continues too long the resultant product will be rich in ash and have little volatile matter. It will therefore lack power.

Sometimes the flames do not stop, and the entire charge is consumed. It is hence better to arrest carbonization too early rather than too late.

Carbonization is stopped by blocking the air inlets. The base of the barrel is blocked first, which quickly stops the production of flames. After a delay of 3 to 5 minutes, the cover is placed on the opening in the upper surface of the drum. It is then covered with sand.

5.5.10 Importance of drum sealing

It is very important to make sure that the barrel remains sealed and does not allow any air flow through the load. Indeed, the slightest air access prevents the load from being extinguished.

5.5.11 Cooling

It takes about 8 hours to cool a barrel. The progress of cooling may be checked by touching the barrel's surface very carefully with the hand. If it is at room temperature, the load is probably off, and the drum can be emptied. A non-cooled down barrel indicates the barrel is not properly sealed and still allow air to access the load which prevents its extinction. Sand must be added to the base and top of the drum.

5.5.12 Make sure the coal is extinguished

Even if the walls of the drum appear sufficiently cool, the carbonized material must be spread on a clean surface when emptying the barrel, to ensure that no more smoke escapes from the product. There is a risk the barrel's content might re-ignite when brought into contact with the ambient air if it is not completely extinguished.

5.5.13 Bagging

After making sure that the product is well extinguished, it can be bagged, pending crushing. It can also be stored in piles (see Pictures 11 and 12).

Picture 11: piled groundnuts shells (cooled) prior to milling

Picture 12: Bags used for carbonized and milled groundnuts shells

5.6 Milling training

5.6.1 Safety rules

Operators should wear appropriate safety equipment: gloves, mask, overalls. The shelter in which the Hammermill is stored shall be well ventilated, to avoid dust accumulation

5.6.2 Different parts of the mill

The hammermill consists of an engine that drives the rotating hammers in the milling chamber. To limit the dust generated by the operation, the operator will take care to properly attach the bag to the outlet of the milling chamber.

The material to be ground is then fed through the hopper, without overloading the engine.

When the bag is full of milled material, it is replaced by an empty bag and the crushing operation can continue.

5.7 Briquette production training

5.7.1 Safety rules

The use of the press can be hazardous and may cause hand injuries if it is not used properly. Compliance with the following rules will prevent accidents. Users must be properly instructed prior to operating the press. The hand that handles the cylinder must always be gloved.

The cylinder must always be held by its side, fingers must never be placed under the base or above the top, where they could be crushed if the press handle is lowered too quickly.

The press handle should be gently lowered and gently placed on top of the cylinder containing the material to be molded as a briquette. Then small shocks and pressure are applied to shape the briquette. Force and pressure have almost no impact on the quality of the briquette.

5.7.2 Proportion and binder preparation

The binder used is starch for ironing clothes or rice, with relative share of 6.5% and 7.5%, respectively. In practice, masses are estimated by the volume: One cup starch powder will be mixed with 17 cups of carbonized powder.

Prior to mixing, the binder needs to be diluted in hot water near boiling temperature (1 cup binder in 5 liters boiling water).

The mix is then left to cool down. Once cold enough the mixture is added to the right amount of powder. Ready to use starch is shown in Picture 13.

Picture 13: Binder, ready to use

5.7.3 Binder and powder mixing

Mixing takes place on the table. The powder is first placed there, then the binder diluted in hot water is added (after cooling). The two materials are then mixed by hand until a homogeneous mixture is obtained. See Picture 14 to Picture 16:

Picture 14: Binder mixing with milled groundnut shells (1)

Picture 15: Pyrolyzed powder and binder mixing

Picture 16: Binder mixing with milled groundnut shells (2)

5.7.4 Placement of operators, equipment layout and work in line

The layout of the table, the press and the drying rack support is important. It must allow operators to be placed in such a way that they can work on the line. The placement of the equipment appears in Picture 17 to Picture 20 which illustrates the work in line.

This equipment must be used by a team of 3 operators, no more, no less.

The first step is to fill a cylinder with the previously prepared mixture, without pressing it excessively. The cylinder is then placed on the press. These actions are those performed by operator 1 in charge of filling the cylinders (on the right in the pictures).

As soon as the cylinder is placed on the press, operator 1 takes another cylinder and proceeds with the same filling sequence.

Meanwhile, operator 2, in charge of pressing (in the centre of the pictures) gently lowers the press handle and places it on the cylinder deposited by operator 1, applying small repeated pressures to compress the material contained in the cylinder. This operation does not require much force, in fact lifting and releasing the handle of the press is enough to shape the briquette. The operator then raises the handle.

Operator 3 (left in the pictures) takes the cylinder on the press, extracts the briquette and places it on the drying rack. Immediately after the removal of the cylinder by operator 3, operator 1 puts a filled cylinder back on the press and operator 2 presses it, so when operator 3 finishes placing the empty cylinder on the table, a new cylinder is already ready to be removed from the press. This cycle is then repeated.

Picture 17: One cup is filled with the Mix, while one briquette is pulled out another cup and arranged on the drying tray.

Picture 18: One cup is taken out the press, while another one is placed.

Picture 19: While one cup is pressed, another one is filled and the third one is emptied:

Picture 20: The empty cup is placed in a place where it is easy to be taken for filling.

5.8 Drying

The racks loaded with briquettes are placed in the sun to dry. The racks have been designed in such a way that they can be stacked.

The drying time required is estimated at 3 days.

It is very important that the briquettes are very dry when used.

- Placing the racks in the sun:
  - Once filled, the trays are transported to be directly exposed to the sun.
- Stacking at night and in case of rain:
  - At night the racks are stacked and covered with a tarpaulin.
  - The same procedure is applied in case of rain.

A demonstration of cooking a meal is carried out by a women or trainer having experience in cooking with briquettes. The briquettes produced by the community are used. The members of the community are supervised, until the use of briquettes is no longer a problem for them. To do this a close follow-up of households using briquettes is necessary.

It appears that by persevering everyone manages to cook with briquettes. If an experienced cooking trainer (used to briquettes) cannot be identified, it will therefore be necessary to give a trainer due time to train himself/herself, prior to the training.

6 Briquette use for cooking training and follow up

The important points to consider are:

- Lighting briquettes takes longer than charcoal.
- The organization of the cooking is different. As briquettes burn faster it is necessary to light the briquettes after cleaning and preparing the food, just before heating. In comparison, charcoal burns slower and allows to proceed to lighting before cooking (cleaning, preparing and heating) the food.
- It is necessary to plan a fuel reload.
- Briquettes, once lighted, cannot be put out, so it is necessary to plan the exact briquette amount which will be used to prepare the meal, so as to avoid waste and additional costs.

The follow-up consists then in helping the users to respect these few rules and to support them in the use of the briquettes till they use it without any problem during cooking. Training will also promote mutual support among users: users who manage to use briquettes without problems (some do so from the first use) helping those who have more difficulty doing so.

When the trainees can easily cook with briquettes, the savings made on the fuel budget are again highlighted.

7 Annex 1: Training evaluation form

Location:		*Date:*	

1. *Respondent details*

Women Group Name		
Member Name		
Gender (delete as appropriate)	Women	Men

2. *Overall impression of the training*

	excellent 1	2	3	4	5 unsatisfactory
Training procedure/steps	❍	❍	❍	❍	❍
Relevance of recycling bio-resources	❍	❍	❍	❍	❍
Training style	❍	❍	❍	❍	❍
Training organisation	❍	❍	❍	❍	❍
Practical (group) work	❍	❍	❍	❍	❍
Materials used	❍	❍	❍	❍	❍
Addressing doubts/questions	❍	❍	❍	❍	❍

3. *Level of knowledge and skill*

	none	*some*	*sufficient*
Measuring and recording proportional quantities of powder and starch	❍	❍	❍
Proper mixture of powder and starch	❍	❍	❍
Filling the piston with the mixture	❍	❍	❍
Proper handling and pressing of the mixture in the piston	❍	❍	❍
Careful removal of pressed briquette and placement on rack	❍	❍	❍
Practical health and safety measures	❍	❍	❍
Recording the time and quantity of briquettes produced per hour	❍	❍	❍
Organising the number of women for the training	❍	❍	❍

4. *Relevance of the training to your livelihood*

To me the training was

- ❍ Very useful
- ❍ Quite useful
- ❍ Interesting, but not useful
- ❍ Useless

5. In one sentence *comments* on your experience during the training

8 Annex 2: Briquette evaluation form

Location:		*Date:*	
1. Respondent details			
Women Group Name			
Member Name			
Gender (delete as appropriate)	Women	Men	
2. Overall impression on briquettes (delete as appropriate)			
My experience with briquette is positive	Yes / No		
I'm using briquettes each day for cooking	Yes / No		
I still use charcoal	Yes / No		
I still use Firewood	Yes / No		
Produce briquette is easy	Yes / No		
Do you think you need more training to be able to cook with briquettes?	Yes / No		
Briquettes are	Expensive / Not expensive Easy to use / Not easy to use Smoky / Not Smoky Other: …… ……		
3. Quantitative information			
How many briquettes were produced by the women group?			
How many briquettes are you using a day?			
What is the cost for these briquettes?			
How much did you spend for cooking fuels before using briquettes (or today if not using briquettes)			
4. *Relevance of the training to your livelihood*			
To me the training was	❍ Very useful ❍ Quite useful ❍ Interesting, but not useful ❍ Useless		
5. In one sentence *comments* on your experience after using the briquette you made (your briquette Moto).			

9 Annex 3: Training implementation

Two types of training are organized: training in the production of carbonized groundnut shell powder (see Table 1) and training for briquette producers and users (see Table 2). The first is organized over 3 days, while the second requires more time, especially for monitoring briquette use, so it is organized over a period of 2 weeks.

	Carbonized powder women groups	
	Day of traini	Content
1	Monday	1 Information / Sensitization
		Briquette presentation and discussion (different from charcoal)
		Project stakeholders (interlinked)
		Women group organisation
		Contact person
		Powder price
		Money management (powder sales)
2	Tuesday	2 Practical session
		Barrel use & carbonized groundnut production
3	Wednesday	3 Practical session
		Grinding

Table 1: Carbonization and grinding training structure

Briquette production & use women groups			
Day of training		Content	
1	Monday	1	Information / Sensitization
			Briquette presentation and discussion (different from charcoal)
			Project stakeholders (interlinked)
			Need for a commitment to use the briquettes
			Focus on use sales are just a side possibility
			Contact person
			Pricing
			Binder price
			Powder price
			Briquettes price & share for the women group
			Water boiling demonstration
			Money (savings) management
2	Tuesday	2	Practical session
			Binder preparation
			Briquette production
			Briquette drying
			Evaluation of the training
3	Wednesday	3	Women group own production
4	Thursday	4	Women group own production
5	Friday	5	Briquettes use
			Cooking with briquettes
			Cooking demonstration
			Common meal preparation
6	Saturday		
7	Sunday		
8-11	Monday-Thu 6-9		Training follow up
			Briquette production
			Focus on briquette use
			Powder order and buy
	Friday	10	Training close up
			Briquette use evaluation

Table 2: Briquetting production and use training structure

10 Annex 4: Report of completed trainings and training evaluation

10.1 Satisfaction questionnaire

After the first two days of training, participants are asked to answer questions in order to complete a questionnaire on their perception of the training (see 10 Appendix 7). These two days correspond to briquette production training.

10.2 Briquette evaluation questionnaire

After two weeks of using briquettes for cooking, users are invited to give their opinion on their experience with the briquettes. The questionnaire is presented in 10 Annex 8.

10.3 Training impact (questionnaire analysis)

N	290	N Women	1	1	1	1	1	1	1	N Some	N Some	N Some	N Some	N Some	N Some	N Some	N Some	N Very Use
% Women	98,3	285	86	168	139	133	129	158	136	85	62	66	80	94	119	130	110	27
		N Men	2	2	2	2	2	2	2	N Sufficient	N Sufficient	N Sufficient	N Sufficient	N Sufficient	N Sufficient	N Sufficient	N Sufficient	N Quite Us
% Men	1,7	5	142	90	110	104	100	83	100	179	221	219	206	191	167	99	174	
			3	3	3	3	3	3	3	N None	N None	N None	N None	N None	N None	N None	N None	N Interesti
			55	29	37	47	51	44	37	26	3	3	2	1	2	60	1	
			4	4	4	4	4	4	4									N Useless
			6	2	3	3	6	3	8									
			5	5	5	5	5	5	5									
			0	1	0	0	0	0	9									

Table 38: Training impact analysis

As shown in Table 38, a total of 290 people were surveyed about their participation in training (not all the 322 trainees mentioned in Table 37 answered the questions). Most participants were women (98,3%), in total only five men participated. The proportions of women and men who participated in the training are also shown in Figure 21, so it appears that activities related to meal preparation, including fuel, are mainly activities performed by women.

As shown in Figure 22 and Figure 23, the evaluation is very positive for the different stages of training or for training as a whole. No participant rated it negatively and 98% found it very useful.

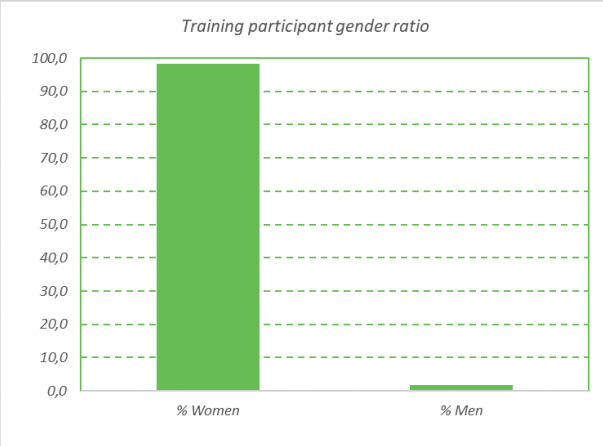

Figure 21: Training participants gender ration

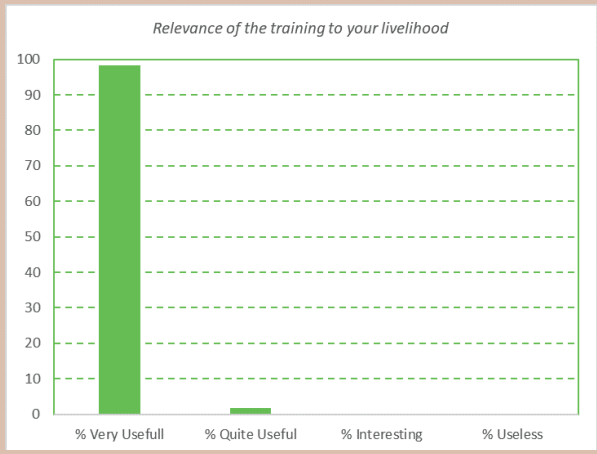

Figure 22: Overall impression of the training, mean values for each item, the lower, the better: value 1 is excellent and value 5 is unsatisfactory.

The first step is to fill a cylinder with the previously prepared mixture, without pressing it excessively. The cylinder is then placed on the press. These actions are those performed by operator 1 in charge of filling the cylinders (on the right in the pictures).

As soon as the cylinder is placed on the press, operator 1 takes another cylinder and proceeds with the same filling sequence.

Meanwhile, operator 2, in charge of pressing (in the centre of the pictures) gently lowers the press handle and places it on the cylinder deposited by operator 1, applying small repeated pressures to compress the material contained in the cylinder. This operation does not require much force, in fact lifting and releasing the handle of the press is enough to shape the briquette. The operator then raises the handle.

Operator 3 (left in the pictures) takes the cylinder on the press, extracts the briquette and places it on the drying rack. Immediately after the removal of the cylinder by operator 3, operator 1 puts a filled cylinder back on the press and operator 2 presses it, so when operator 3 finishes placing the empty cylinder on the table, a new cylinder is already ready to be removed from the press. This cycle is then repeated.

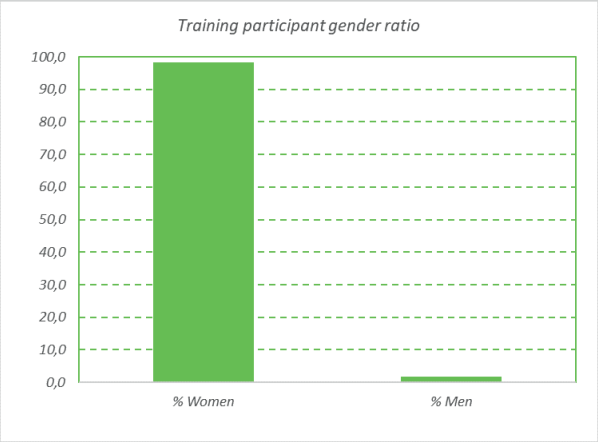

Figure 23: Opinion about the training relevance after first two days of training (production)

10.4 Briquette acceptance (questionnaire analysis)

After the briquette production training, a sample of participants (77) were again asked the same question about the usefulness of the training (Figure 24). In this case 100% of respondents considered it "very useful". Thus, the evaluation at the end of the briquette use period is improved compared to the one, already very good, obtained at the end of the production training. This could be due to a positive effect of the use of briquettes on participants' opinion.

Feedback on the use of briquettes is also very positive (Figure 25): 100% of respondents consider it a positive experience, 75% of respondents say they use briquettes every day, respondent, however, state that they do not exclusively use briquettes and continue to use charcoal (71%) and firewood (5%), over 90% of respondents consider it easy to produce briquettes but want more training in their use, but some of them claim for more trainings (44%), the image of fuel is particularly good among households that have tested it. Indeed, the last 3 questions intended to evaluate this aspect (expensive/ cheap, easy to use or not, smoky or not) each receive a 100% positive rating.

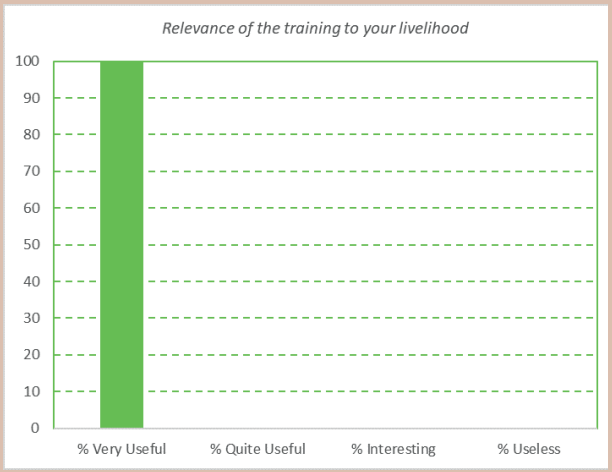

Figure 24: Opinion about the training relevance after using briquettes

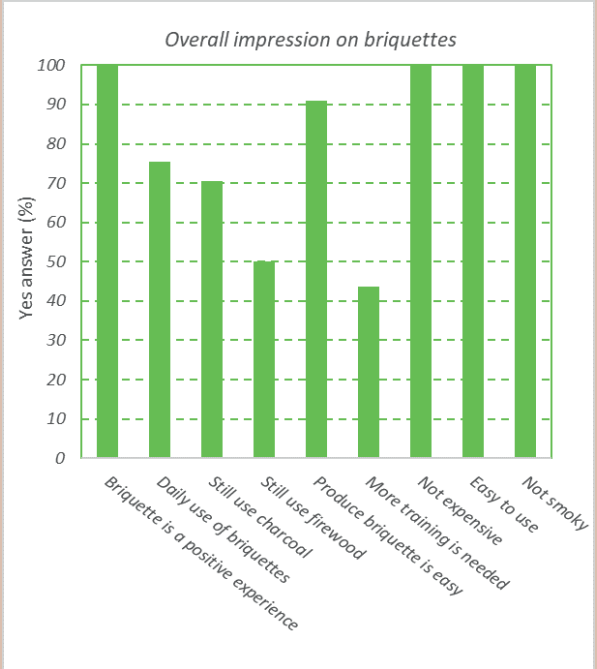

Figure 25: Overall impression of trainees about briquettes, percentage of Yes answer to the asked questions

7.5 Briquette production follow-up

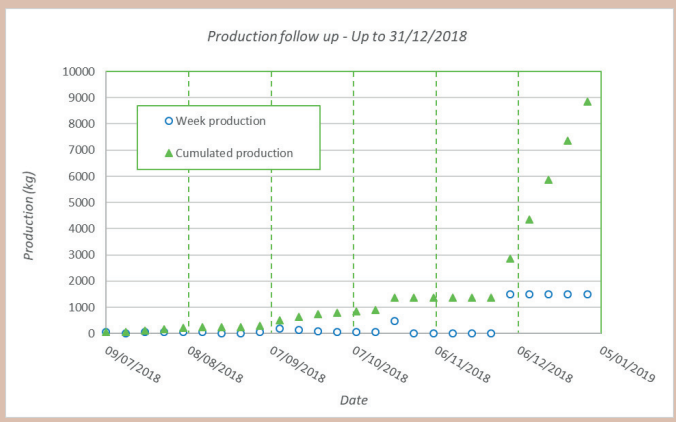

Figure 26: Carbonized ground nuts shells production at Saro follow-up

Briquette production took time to set up. It only reached its nominal production from the beginning of December 2018. Since then, 1500 kilos of carbonized and milled groundnuts shells have been produced each week and taken to the various womens groups to be transformed into briquettes and used to replace charcoal or firewood. From the beginning, a bit less than 10 tonnes briquettes have been produced. Since the equipment provided by the TA is fully in operation, it produces 6 tonnes briquettes/month.

Recycling of Organic Waste for Energy and Smallholder Livelihood in The Gambia

Briquette production manual