



INTERNATIONAL NETWORK FOR BAMBOO AND RATTAN

MANUAL ON BAMBOO CHARCOAL AND BRIQUETTE PRODUCTION AND UTILISATION



TRANSFER OF TECHNOLOGY MODEL

EC/INBAR SUSTAINABLE BAMBOO BIOMASS ENERGY FOR AFRICA PROJECT



International Network for Bamboo
and Rattan



European Union

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Bamboo as Sustainable Biomass Energy: A Suitable Alternative for Firewood and Charcoal Production in Africa

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ABOUT THIS MANUAL

This Transfer of Technology Model is aimed at providing farmers, households, communities, and micro small charcoal producing enterprises with basic information on bamboo charcoal production and utilisation, with special emphasis on brick kiln construction and operation. It outlines the basic activities involved in bamboo charcoal production and takes the reader through a stepwise construction and operation of the brick kiln and the production and utilisation of the bamboo charcoal. This interactive manual is developed in simple language and can be readily used by all manner of charcoal producers.

It is, essentially, intended as a practical information resource and teaching aid for those at the local extension levels in their communities, who can utilise them to assist local communities in the utilisation of bamboo for charcoal production.

This manual has been developed as part of the International Network for Bamboo and Rattan (INBAR) and European Union's project on *Bamboo as Sustainable Biomass Energy: A suitable Alternative for Firewood and Charcoal Production in Africa*. Following the pressure on the natural forest, and the timber resources in particular, bamboo charcoal is the suitable alternative that appear to be both affordable and workable. It will help in satisfying the burgeoning demand for wood and charcoal, ease the conservation of sustainable management in the natural forest and reduce its associated environmental impacts.

The project is aimed at increasing the use of bamboo as source of energy for low income households in targeted Ghanaian and Ethiopian urban and rural communities, low income charcoal producers and micro small enterprises involved in charcoal production by producing more sustainable, environmental friendly and economic option to firewood and wood charcoal.



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BAMBOO CHARCOAL BRICK KILN

A bamboo charcoal brick kiln is a thermally insulated chamber made up of bricks in which a controlled temperature regime is controlled for carbonising bamboo through pyrolysis. It normally has a half-round shape with a doorway which is closed with bricks during charcoal production. After loading the kiln with bamboo, the doorway is partially closed leaving two openings for ignition and temperature control (see Plate 1). The kiln has another opening at the upper part which serves as smoke hole or outlet (see Plate 3). Properly constructed and operated brick kilns are without doubt one of the most effective methods of charcoal production.



Plate 1: Front view of a brick kiln showing the doorway



Plate 2: Aerial view of an uncompleted kiln



Plate 3: Chimney of a bamboo charcoal kiln



Plate 4: Brick laying with gravels providing support at the clay mortar joints

MATERIALS AND EQUIPMENT REQUIRED FOR KILN CONSTRUCTION

The quantity of materials required for bamboo kiln construction may vary depending on the desired size or capacity of the kiln. Following is an estimate for the construction of a kiln with a capacity of 5 tonnes:

Material/Equipment	Quantity
Burnt bricks	4000
Roofing sheets	17 sheets
Bamboo firewood	1 tonne
Wood for shelter construction (4x4in)	15 pieces
Nails (4 and 6 inches)	1 packet
Gravels	20 kilograms
Water	3000 gallons
Clayey soil	3 cubic meters
Fine sand	3 cubic meters
Soil	20 cubic meters
5 inch cement blocks	350
Cement	5 bags
Spade	2
Head pan	2
Cutlass	2
Mattock	1
Long rope	1
Wheel barrow	1
Measuring tape	1

CHOOSING A SITE FOR KILN CONSTRUCTION

Generally, bamboo brick kilns are constructed in open places. The following factors may be considered in selecting an appropriate site for constructing a kiln:

1. Raw material availability

The site must be preferably close to the bamboo plantation or farm in order to ensure easy access and reduce transportation cost.

2. Proximity to a major road

Closeness to a major or pliable road makes transportation of products and raw materials relatively easier.

3. Marketing area

Nearness of the site to a marketing area could cut down the cost of transporting products to the market.

4. Proximity to construction materials

Proximity of the site to building materials such as clay, sand and water could reduce the cost of transportation.

5. Availability of labour

Even though bamboo charcoal production is not a labour intensive venture, the services of a carpenter, mason and, depending on the production capacity, harvesting of bamboo culms and operating the kiln.

6. Environmental impact and waste disposal

The possible environmental impact of the construction and operation of the kiln should be considered. Marshy areas should be avoided. Farmers can apply the ash produced during charcoal production on their farms to improve the soil fertility. It could also be used for soap production.

BAMBOO BRICK KILN CONSTRUCTION

The bamboo brick kiln is constructed as follows:

Site preparation

After site selection, the land is cleared. Compact the land lightly and fill with sand to bring it back up to the level of the site as a whole to allow easy drainage of water away from the kiln.

Design of the kiln

The design of the kiln is as shown in Plate 8. It is completely built with bricks, with cement block wall around it and filled with sand to support it and keep in the heat (see Plate 9). Clay and water are used as mortar, usually with no iron or steel support. The shape is hemispherical, of diameter of about 6m. A total of about 4000 bricks are required, making allowance for breakages during construction.

The kiln has two openings, diametrically opposite each other. The line of the openings must be perpendicular to the direction of the prevailing winds. The height of each opening is 1.5m. One opening serves as the door and the other as the smoke exit. The height of the door is 1.5m, width at the bottom is 50 - 80cm and at the top 40 - 70cm.

The door is used for controlling the kiln temperature, charging the kiln with bamboo culms and bamboo firewood, and discharging charcoal (see Plate 10). The size of the smoke exit opening is a brick (see Plate 6). A brick chimney is built to protect the smoke exit opening and to direct the smoke out of the kiln (see Plate 5).

The kiln door is closed with bricks built up after the charge is completed. This simple operation is repeated each time the kiln is charged. It only involves placing brick over brick and covering with clay mortar. Approximately 80 bricks are needed for the door and they can be used until the bricks start to break.



Plate 5: Brick chimney



Plate 6: Smoke exit opening



Plate 7: Side view showing the brick kiln and the cement wall



Plate 8: Perspective view showing the cement block wall and two brick kilns under construction



Plate 9: Packed bricks ready for use

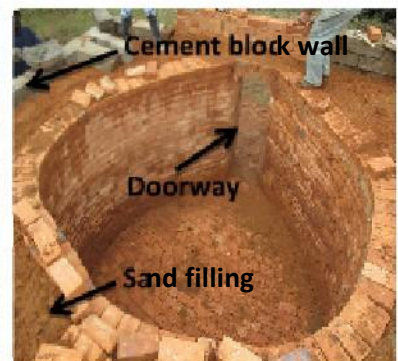
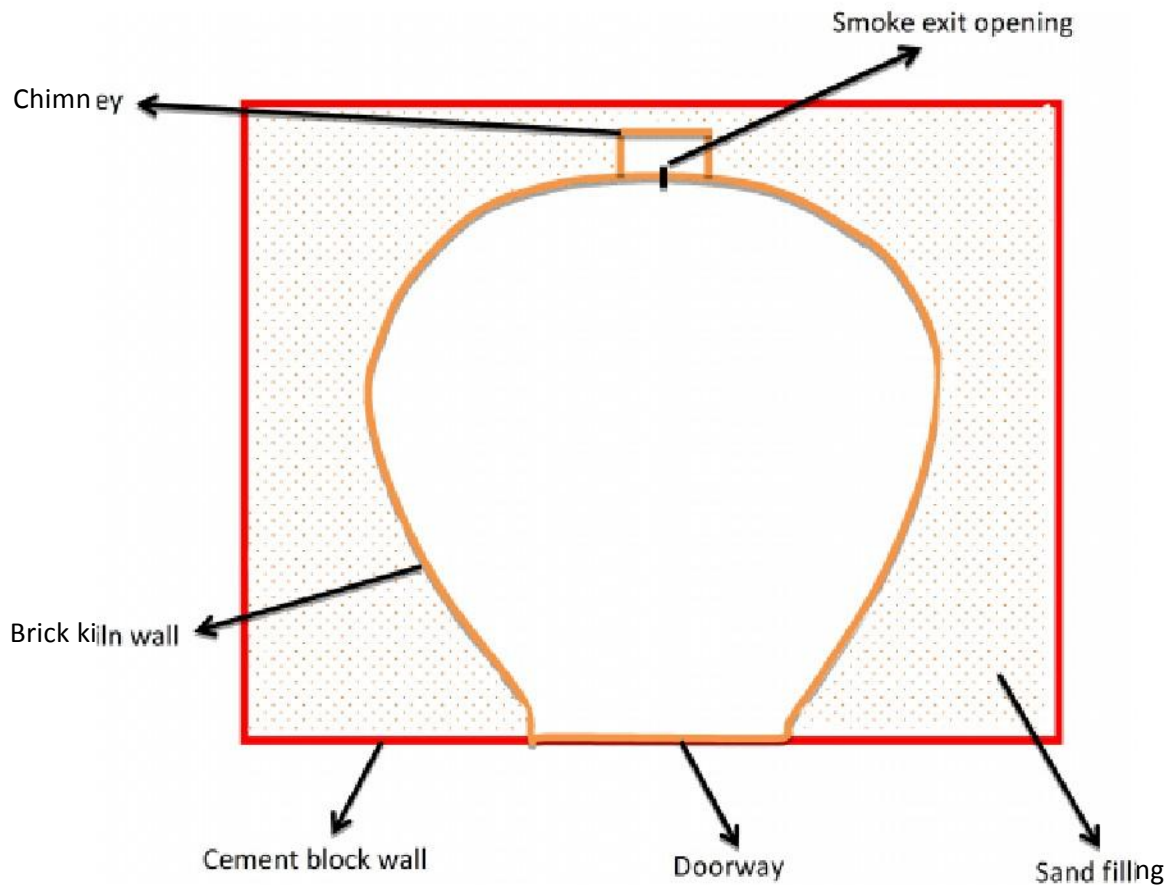


Plate 10: Aerial view of the kiln showing the doorway, cement wall and sand filling

Plan of the kiln



Building the foundation

The foundation layout is done according to the plan of the kiln. Ideally, the doorway must be perpendicular to the prevailing winds.

Layout

The foundation is done as follows:

1. Determine where the front of the kiln will face by considering the wind direction and the ease of operating the kiln.
2. Decide the first corner and peg it.
3. Use the 3-4-5 method (i.e. the three sides of the triangle measures 3, 4, and 5 feet or meter) to set the corners of the kiln and peg them.
4. Using the pegs as guide, draw the triangular shape of the kiln on the ground which indicates the inner wall of the kiln.
5. A 50cm gap is left for the doorway.
6. A gap of the size of a brick is left directly opposite the doorway as an opening for smoke exit.

7. Draw the foundation line of the chimney.
8. With the help of ropes and pegs draw the foundation line of the external cement block wall and remove the topsoil and debris.
9. Remove the topsoil and the debris on the foundation line.

Laying bricks and blocks

The mortar used for laying bricks is made of clay and water while the one for laying cement blocks is cement mortar. Ropes should be used to ensure proper alignment of bricks and blocks. The block and brick laying, as well as filling of the gap between the brick kiln and the cement wall with sand, is done simultaneously (see Plate 10). The sand is pressed to support the kiln and prevent leakage of heat from the kiln. Blocks and bricks laying is done carefully to ensure that the same shape is maintained from the foundation level to the dome level. Gravels are used to support the clay mortar joints (see Plate 14). A wooden door frame, measuring 50cm at the base, 40cm at the top and 1.5m in length is fixed at the doorway to help in shaping it (see Plate 14). Sticks are used to support the construction of the upper curve of the door (see Plate 13).



Plate 11: Arrangement of the first layer of bricks



Plate 12: Door frame for shaping the doorway



Plate 13: Sticks used for supporting the arc of the doorway



Plate 14: Gravels used for supporting the mortar joints

Kiln Dome Construction

The construction of the dome begins at the lintel level of the kiln. Fill and press the sand to the lintel level before the dome construction. Care should be taken not to cover the chimney with the sand. Brick laying is done carefully at this stage. Bricks are laid in an oblique fashion to close the dome. After construction, the dome is covered with sand.



Plate 15: Inner perspective of dome closure



Plate 16: Outer perspective of dome closure

Shelter Construction

A shelter is constructed over the entire kiln to prevent the rain from getting to it to reduce the heating level during the carbonisation process. This helps to improve the quantity and quality of charcoal produced. Kilns with shelter last longer.



Plate 17: Roofing of shelter



Plate 18: Kiln shelter construction

LOADING THE BRICK KILN

The culms should be dried for about four days before loading. A few uniform-sized culms are laid out to serve as a platform to allow air circulation at the base of the kiln (see Plate 19). Arrange culms layer by layer to ensure that all gaps at the curved edges are filled. Culms are arranged with the smaller end of the culm downward. Good quality culms are arranged at the back while those of poor quality are arranged in the front part near the fire. A space of about half a meter is left between the culms and the doorway for loading bamboo firewood.



Plate 19: Arrangement of the platform



Plate 20: Loaded bamboo culms in a kiln

IGNITING AND CLOSING THE BRICK KILN

After loading, the doorway is partially closed with bricks leaving an opening at the bottom for ignition and in the middle for air intake and temperature control. The bamboo firewood is then ignited. The firewood is added as and when it is consumed and ash produced is removed from the kiln. The two openings may be closed at about 20 to 40 minutes after ignition. Ideally, a change in colour of the smoke is used to determine when to close the openings to cut out supply of oxygen into the kiln. If the kiln is closed too late, the temperature inside will be too high and may result in a total burnout or reduced charcoal production.



Plate 21: Bamboo firewood for ignition



Plate 22: Ignited bamboo firewood in a kiln

CONTROLLING THE BURNING PROCESS

The burning process depends on a number of factors such as the diameter and moisture content of the bamboo, wind direction and force. Handling of the process therefore requires a lot of experience and intuition. Communities or groups can perform a person or two to control the burning process. The changes in the colour of the smoke from the chimney could be used to determine the phase of the burning process and the necessary action to take.

Burning Phase

At the beginning, when the moisture content is being driven off, the smoke is white and thick. The white smoke will continue for several hours. All observed leakages must be sealed with clay and sand.

Charring Phase

The smoke turns from grey to bluish. The bluish colour is an indication that the proper charring process has started. The smoke exit is then closed with bricks. The charring process is complete when the smoke colour changes from blue to almost clear.

Cooling Phase

The cooling phase then starts. This phase will last for about 48 to 72 hours.

All things being equal, the entire process will last for about 5 to 8 days by which time the outside of the kiln has cooled down.

REMOVING THE BAMBOO CHARCOAL

The kiln should be opened only when it has cooled down to avoid oxygen from igniting the remains of glow. Ideally, a rake is used for removing the charcoal onto a material to prevent them from mixing with soil.



Plate 23: Bamboo charcoal ready for unloading



Plate 24: Unloading charcoal with rake collection to prevent contamination



Plate 25: Material used for collection to prevent contamination

QUALITY CONTROL

Examine the charcoal to ensure that they do not have any self-igniting tendencies and also they are well-formed and free from foreign materials.

SORTING AND PACKING

After unloading the bamboo charcoal from the kiln, well-formed ones are separated from broken ones and packed into sacks. The broken ones are packed into sacks for briquette production.



Plate 26: Sorting to separate well-formed one from broken ones



Plate 27: Packing charcoal into sacks



Plate 28: truck loaded with charcoal for transportation

BAMBOO BRIQUETTE PRODUCTION

Bamboo briquette is produced as follows:

1. Crash or grind the broken bamboo charcoal in a head pan into the powdered form.
2. Add clay to the powdered bamboo charcoal in the proportion of 1 part of clay to 3 parts of charcoal. Too much clay will produce poor quality briquette.
3. Add water to mix.
4. Fill the simple moulding machine with the mixture and press to form the honey comb briquette. The comb is then dried.



Plate 29: Mixing clay and powdered charcoal with water



Plate 30: Pressing the mixture to mould the briquette



Plate 31: Moulded briquette

HEALTH AND SAFETY MANAGEMENT

Bamboo charcoal kiln construction and operation involves risk. The handling of tools and equipment, as well as the actual construction work may be dangerous. Again, because of the high temperatures involved in the operation of the kiln, working conditions may be dangerous if the work is not carefully planned and implemented.

Workers must not perform a task they are not equipped to do.

All workers must observe safety precautions at the work place to avoid accidents.



Plate 32: A worker working with protective gear

BAMBOO CHARCOAL AND BRIQUETTE UTILISATION

Bamboo charcoal and briquette is largely used for cooking and heating. Other uses include soil improvement (biochar) and water purification.



Plate 33: Ignited bamboo charcoal in a pot

TECHNICAL SUPPORT

INBAR has trained individuals and groups in the various communities in Ghana who are willing to assist people to produce bamboo charcoal and briquettes. Help can also be obtained from INBAR's Technology Transfer Centre at Daboase and the Training Centre at Tandan in the Western Region of Ghana or at INBAR's office in Kumasi.



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