BIOMASS BRIQUETTES
PRODUCTION HANDBOOK

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Biomass Briquettes Production Handbook

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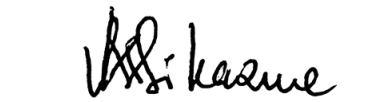

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Introductory Note

This handbook has been prepared as part of a project implemented by Tanzania Industrial Research and Development Organization (TIRDO) and REPOA in effort to address climate damage caused by uncontrolled cutting of trees for firewood and charcoal production. Tanzania has not fully addressed the issue of climate effects resulting from dependence on biomass (firewood and charcoal) as primary source of energy for households. About 90% of the Tanzanian population depend on biomass (firewood and charcoal) energy for domestic cooking and heating. Cutting of trees for charcoal production has contributed to deforestation and land degradation, carbon dioxide emissions, watershed destruction, and biodiversity loss. On top of that, smoke from firewood and charcoal, contributes to negative health effects like respiratory illness and premature birth. It is evident and strongly argued that the use of locally available and affordable alternative energy reduces the prevalence of this problem.

TIRDO in partnership with REPOA has implemented a two-year project to address the issue of low adoption of biomass briquettes as a substitute for firewood and charcoal. The focus of the project is to identify key players in biomass briquetting from production to end users. The project also examines the current status on production capacity, technology used, challenges facing producers and end users, then bring about solutions tailored to fit with what has been observed on the ground. This includes preparation of formulae for production of biomass briquettes using

raw materials found in Tanzania, improve production technology by designing and fabricating machines so as to ensure good quality of the final product. The project also looked at ways of lessening harms to the environment by reducing dust, and smoke from biomass pyrolysis, and noise from grinding of materials. The improved technologies including formulae and machines are disseminated to the public for consumption to accelerate the use of biomass briquettes as an alternative to charcoal and firewood. Among the knowledge dissemination tools is the handbook that explains various steps to follow in order to produce quality biomass briquettes.

The handbook helps biomass briquette producers, related stakeholders, and those planning to start this business by providing specific guidelines on quality biomass briquette production.

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SECTION 1

1 GENERAL OVERVIEW OF BIOMASS BRIQUETTING

1.1 Introduction

Biomass is a renewable organic material that comes mainly from plants and animals. In other words, it refers to plant materials and animal waste used, especially as a source of fuel. In the context of energy production, biomass materials include agricultural residues, forest waste, municipal organic waste, animal manure and human sewage (Figure 1.1). Biomass can be converted into fuel in the form of liquid, gases and solids through various processes including biochemical (e.g., anaerobic digestion) and thermochemical (e.g., pyrolysis and combustion) methods. Factors determining the choice of methods depend on among other things the biomass materials properties (e.g., type, physiochemical properties, and quantity), the desired type of fuel, available technology, the end use requirements, the health and environmental standards, as well as the economic situations.

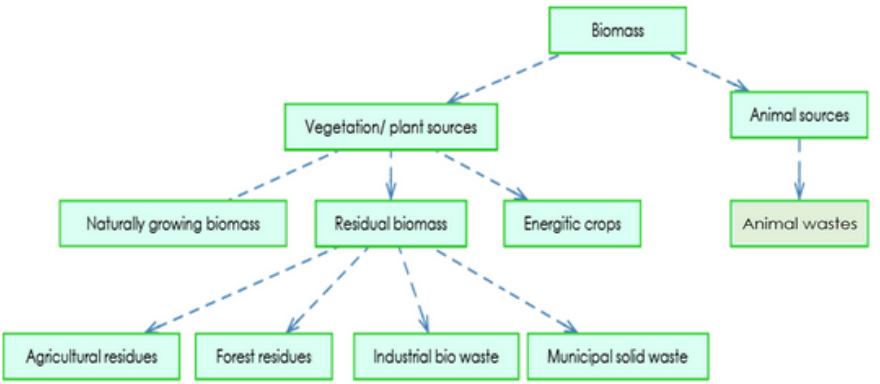

Figure 1.1: Classification of biomass

It is foreseen that for many decades to come biomass will continue to be a crucial energy-source for domestic cooking in sub–Saharan Africa. In Tanzania, estimates show that about 90% of the population depends on biomass energy for the same. Owing to the advantages that biomass energy offers in terms of its renewability, affordability and energy diversification and security, briquetting technology has often been promoted. The technology involves densification of loose biomass materials to form briquettes that have improved handling characteristics and are considered to be a climate smart alternative to wood fuels. In the recent past, the use of biomass briquettes has been promoted in the country; however, their adoption has remained low despite their many advantages.

A recent survey conducted by TIRDO in collaboration with REPOA revealed that poor technology and inadequate knowledge also contribute to production of poor briquettes, which in turn, are rejected by customers and users. Therefore, improving the quality of biomass briquettes is very important in order to substitute wood fuels. This handbook outlines steps to take in order to produce high-quality biomass briquettes.

1.2 Objective of this Handbook

The objective is to illustrate a simple scientific step-by-step process of producing good biomass briquettes sustainably.

1.3 The Scope of the Handbook

This handbook covers:

- General overview of the briquetting process,

- Practical guidelines on how to produce biomass briquettes,
- Approaches to follow, to ensure sustainability of biomass briquette production.

1.4 Why Biomass Briquetting?

Loose biomass materials (carbonized or uncarbonized form) cannot give a good quality combustion when applied as an alternative energy source for domestic and industry use. Thus, to make effective use of biomass materials, briquetting is employed to improve the handling characteristics of the biomass material, increase the volumetric value, and make it available for a variety of applications. In addition, briquettes possess high burning efficiency due to its low moisture content and high density. Therefore, they have higher practical thermal value and much lower ash content though their efficiency depends on the nature of materials.

SECTION 2

2 MAKING OF BIOMASS BRIQUETTES

Biomass briquetting process involves raw materials collection, preparation, carbonizing, grinding, mixing of the materials, binding, compacting, drying, and packaging (Figure 2.1). There are two main types of raw materials which are biomass materials and binders. The specific steps for making of biomass briquettes are presented as follows.

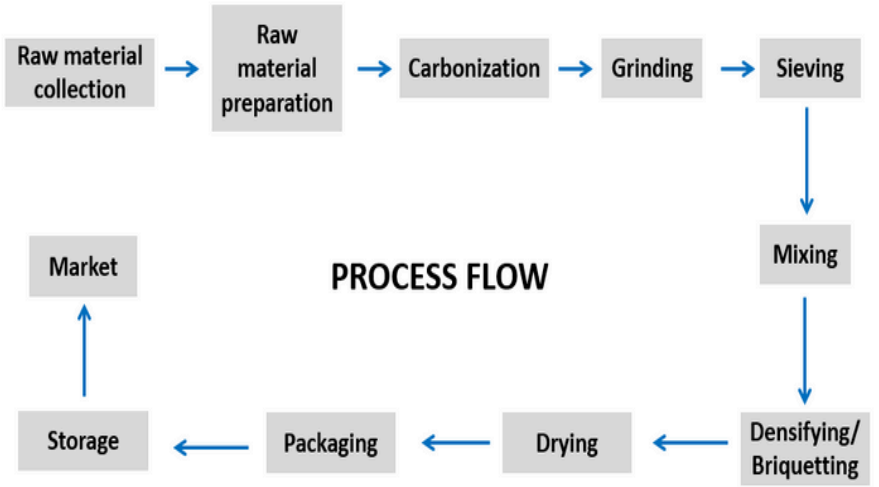

Figure 2.1: General biomass briquettes production process

2.1 Sourcing and Collection of Biomass Raw Materials

The process of sourcing and collection of raw materials (Figure 2.2) before biomass briquetting can vary depending on the type of material being used and the location of the production facility. Selection of materials depends on the availability, accessibility, affordability, quantity, quality, technology, cost and preference.

Figure 2.2: The biomass raw materials for briquette production.

2.1.1 Biomass Materials

The steps that can be followed to source and collect raw materials for biomass briquetting include identification of potential source; assessment of the quality and availability; and collection of raw materials as detailed below:

a. Identification of potential sources: The first step is to identify potential sources (eg. farms, forests, industries, market) of raw materials. This may involve conducting research, contacting suppliers, or working with local communities and farmers. The potential sources include forests, farms, markets, dump sites, agro-processing and wood processing industries.

b. Assessment of quality and availability: Once potential sources of raw materials have been identified, it's important to assess their quality and availability. This may involve visiting potential suppliers and conducting laboratory tests to ensure that they meet the minimum national and international required standards as may be applicable. It is advised to take samples to a quality energy laboratory for solid fuel analysis and get

technical advice for improvements if any before producing briquettes. The important quality parameters to test include ash content, volatile matter, calorific value, moisture, and fixed carbon.

c. Collection of the raw materials: The raw materials can be collected from the sources and transported to the production facility. It is important to ensure that the raw materials are handled carefully during transportation. Should a need arise for storage of raw materials mid journey, store them in conditions that will not alter its quality. The room temperature should range between 25 °C and 30 °C and relative humidity between 40% and 60%.

Summary

Depending on the type of raw materials being used, there may be additional steps that might be involved in the sourcing and collection process. For example, if the raw materials are sourced from forests or other natural habitats, it may be necessary to obtain permits from designated authorities or work with local communities to ensure sustainable sourcing practices.

2.1.2 Preparation of the Biomass Materials

Preparing the raw materials before biomass briquetting is an important step that can greatly impact the quality of the biomass briquettes. Preparation of the biomass materials entails sorting and cleaning of the raw materials; drying; pyrolysis or carbonization; griding; and sieving as described below:

a. Sorting and cleaning

The biomass materials should be free from unwanted substances like stones and pieces of metal. This can be achieved primarily by being careful at the collection stage not to include unwanted materials. It can also be done by hands if the quantity of raw material is not at industrial scale and if the size of unwanted materials is big enough to be picked by hand. Otherwise sieves and advanced machines may be required.

b. Drying

Raw materials that contain high levels of moisture should be dried before pyrolysis or carbonization process. Moisture content of biomass material should be less than 12%. Drying helps to remove excess moisture, which can lead to long carbonization time and reduction of the efficiency of carbonization process. For fecal sludge, dewatering should be employed to reduce large quantity of water before drying process.

c. Pyrolysis or carbonization

This is a process of making biochar or charcoal from raw biomass materials by subjecting the biomass material to heat with limited supply of oxygen to remove volatile matter, also known as smoke. Generally, for effective pyrolysis, the temperature should be at a range between 350 °C and 450 °C. Time to be taken for this process is often 6 to 8 hours. However, the time for the container and pyrolyzing equipment usually take longer. Therefore, the process of pyrolyzing one batch usually takes one day considering time to set

up the fire, flue gas release, burning of the remaining fuel that started the fire, and cooling of the entire system.

Note: Pyrolysis is a thermo-decomposition of materials subjected under heat with limited supply of oxygen. Thus, during the process, temperature and pressure build up in the carbonization chamber. Therefore, workers should be warned against any attempts to open the carbonization chamber when the process is underway to avoid complete combustion of the materials and sudden heat wave that could harm the operator.

d. Grinding

The next step is to grind the carbonized or pyrolyzed raw materials into small particles whose sizes ranging from 0.1 mm to 4 mm. This helps to increase the surface area of the raw materials and makes them easier to handle during the briquetting process. It is important to note that this is only necessary if you carbonize biomass materials before making briquettes. However, for uncarbonized biomass briquettes and pellets production, grinding should be done after drying the material at a desired moisture content level, usually 8-12%.

e. Sieving

Sieving is done after grinding of carbonized biomass raw material, to remove any oversized or undersized particles. This helps to ensure that the raw materials have a consistent size ranging from 0.1 mm to 4 mm, which is important for producing uniform briquettes.

By following these steps, the quality of raw materials for biomass briquetting can be improved, consequently improving the quality

of the final product. It's important to choose the right raw materials and to ensure that they are properly sorted, cleaned, shredded, dried, sieved, and mixed before the briquetting process begins.

2.2 Sourcing and Collection of Binder Materials

A binder is a material that is added to the biomass material to hold it together during the compaction process. There are different types of binder materials which originate from different sources. Figure 2.3 shows some of the common binders which are mixed with biomass materials. The main binding materials include starch; molasses; clay; and gum arabica as described below:

Figure 2.3: The common types of binder used in production of biomass briquettes.

2.2.1 Binder Material

a. Starch

This is the most preferred binder used in the production of biomass briquettes. It is generally obtained from grains of corn or wheat, as well as from tubers like cassava. Starch can be bought from markets or self-prepared.

b. Molasses

Molasses is a by-product of the sugar refining process. Molasses can be bought directly from sugar industry or specific supplier at the market. Briquettes bound by molasses burn well, but they have unpleasant smell during combustion. In order to avoid this, thermal treatment (curing) can be applied before using such briquettes.

c. Clay

Clay is a natural binder that can be obtained from clay soil. It is widely available at almost no cost in many areas. Clay does not add to the heating value of briquettes. Thus, if too much clay is added, the briquettes will ignite and burn poorly or not at all. Besides, clay will turn into ashes after burning, which blocks the flow of radiant heat, leading to the loss of heating value of the biomass briquettes.

d. Gum arabic

This is a natural binder harvested from acacia tree. It can also be bought from the market. It does not emit heavy smoke therefore; no thermal treatment is needed.

2.2.2 Binder preparation

The preparation of a binder for biomass briquetting depends on the type of binder being used. The following are some general guidelines on preparing different types of binders:

a. Starch

To prepare a starch binder, mix starch powder with water and cook it to form gelatinized solution. The quantity of the starch solution

depends on the type or nature of the biochar material of the briquettes. Typically, a concentration of 10-25% in gelatinized form is used for most biomass materials.

b. Molasses

This is prepared in different ways depending on its viscosity. On the one hand, if it is of high viscosity (difficult to flow/pour freely), mix it with water in a 1:1 ratio. The mixture should then be heated to a temperature between 60-70 ℃ to dissolve the molasses. On the other hand, if mollasses can flow freely, it can be used directly without any addition of water.

c. Clay

Clay is the natural binder that is used in biomass briquetting. To prepare a clay binder, mix clay powder with water (15 to 25%) to form a paste. The paste should be left to stand for a few hours to allow the clay to fully absorb the water. Alternatively, the clay binder can be used directly in a dry state mixed with biochar followed with addition of the required amount of water.

d. Gum arabic

To prepare a gum binder, mix it with water in a 1:1 ratio. The mixture should be heated to a temperature between 80-90℃ to dissolve the gum.

Summary

When preparing a binder, it's important to ensure that it is well-mixed and evenly distributed throughout the biomass material (biochar). This can be done by mixing the binder with the biochar

in a mixer or by adding the binder to the biochar in a spraying/dropping process. The amount of binder added depends on the type and quality of the biomass material being used.

Overall, the preparation of a binder for biomass briquetting is a crucial step in the briquettes production process. The right binder helps to improve the quality of the briquettes, making them more compact and stable. It's important to choose a binder that is compatible with the biomass material being used and to ensure that it is added in the right amount to achieve the desired results (Table 2.1).

Table 2.1. Binder preparation

Binder	Form	Preparation	Boiling
Starch	Liquid	Dilution	Yes
Clay	Solid	Dry	No
Clay	Solid	Dilution	No
Molasses	Liquid (high viscous)	Dilution	Yes
Molasses	Liquid	As sourced	No
Gum Arabic	Solid	Dilution	Yes

Source: Tanzania Industrial Research and Development Organization

2.3 Mixing Biomass with Binder

When producing biomass briquettes, it is often necessary to add a binder to the biomass material to help it stick together and form solid briquettes. As emphasized earlier, it is important to ensure that the binder is evenly distributed throughout the biomass material. This is done by mixing the binder with the biomass material in a mixer

or by adding the binder to the biomass material in a spraying process. The amount of binder added depends on the type and quality of the biomass material being used and the desired quality of the briquettes. As stated earlier, it is important to choose a binder that is compatible with the biomass material being used and to ensure that it is added in the right amount to achieve the desired results. The Table 2.2 indicates the possible mixing quantity of binder (ranging from 20 to 30) and biochar material (ranging from 70 to 80) by percentage weight (%wt) depending on the nature of the material.

Table 2.2. Mixing ratio for binder and carbonized biomass

Binder	**Biochar/Charcoal material**	**Possible Mixing Ratios (wt/wt) %**
Starch	Charcoal dust	20-25:75-80
	Coconut shell dust	20-25:75-80
	Palm Kernel dust	20-25:75-80
	Rice husk	20-25:75-80
Clay	Charcoal dust	20-30:70-80
	Coconut shell dust	20-30:70-80
	Palm Kernel dust	20-30:70-80
	Rice husk	20-30:70-80
Molasses	Charcoal dust	20-25:75-80
	Coconut shell dust	20-25:75-80
	Palm Kernel dust	20-25:75-80
	Rice husk	20-25:75-80
Gum Arabic	Charcoal dust	20-25:75-80
	Coconut shell dust	20-25:75-80
	Palm Kernel dust	20-25:75-80
	Rice husk	20-25:75-80

Source: Tanzania Industrial Research and Development Organization

2.4 Briquette Production

As introduced earlier, this is the process whereby the mixture of biomass char(biochar) material and binder are compressed to form solid biomass briquettes that are used as a fuel source. Here are some common methods used to compact biomass briquettes.

2.4.1 Screw Extrusion

This is one of the most common method used for making biomass briquettes. The process involves feeding the mixture of biochar and binder materials into a screw extruder, where it is compressed to form a dense briquette (Figure 2.4).

Figure 2.4: Screw Extrusion briquetting machine (making cylindrical briquettes)

2.4.2 Roller Press

This is also the most common method used for making biomass briquettes. The process involves feeding the mixture of biochar and binder materials into rollers, where it is compressed to form briquette (Figure 2.5).

Figure 2.5: Roller press briquetting machine (making oval briquettes)

2.4.3 Piston Press

This method involves using a piston to compress the mixture of biochar and binder materials into a dense briquette. The material is fed into a cylinder, where a piston compresses it under high pressure, causing it to form a solid briquette (Figure 2.6).

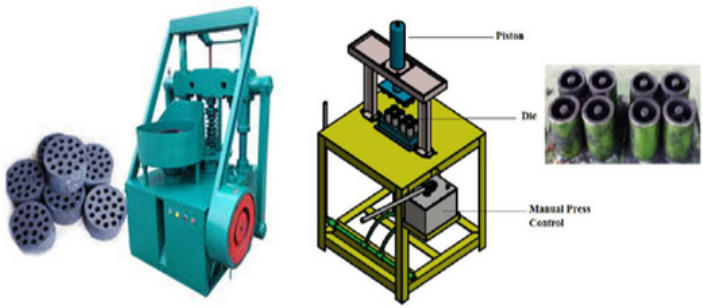

Figure 2.6: Piston press briquetting machine (Automatic (left) and Manual (right))

2.4.4 Hydraulic Press

This method involves using a hydraulic press to compress the mixture of biochar and binder materials into a dense briquette. The material is placed in a mold, and a hydraulic press is used to apply high

pressure to the mold, causing the material to form a solid briquette (Figure 2.7).

Figure 2.7: Hydraulic press briquetting machine

Summary

Overall, the methods used to compact biomass briquettes depend on the availability of resources, the required quality and quantity of briquettes, and the equipment and operators' skills. It is important to choose a method that ensures the briquettes are dense, uniform in size and shape, and suitable for use as a fuel source.

2.5 Drying of Biomass Briquettes

Drying biomass briquettes is an important process that helps to improve their quality and stability, as well as increase their energy density. Here are some common methods used for drying biomass briquettes.

2.5.1 Sun Drying

This is the most common method of drying biomass briquettes. The briquettes are spread out on a flat surface, exposed to direct sunlight, and turned regularly until they are completely dry.

However, as mentioned earlier, prolonged exposure to sunlight causes the briquettes to deteriorate and lose their structural integrity, so it is important to monitor them closely and bring them inside if there is a risk of rain or strong sunlight. This method is weather dependent hence it might result into prolonged drying period (Figure 2.8).

Figure 2.8: Sun drying of biomass briquette

2.5.2 Hot Air Drying

This is the type of drying method whereby the heat required to remove water from briquettes is carried by the generated hot air. The hot air passes through the briquettes to be dried and exits from the drier through an outlet.

2.5.3 Open Air Drying

This involves leaving the briquettes in a well-ventilated area to dry naturally (Figure 2.9). The briquettes are placed on racks or hung up in a dry, cool place where air circulates around them. This method can take several days, depending on the humidity levels and temperature.

Figure 2.9: Air drying

2.5.4 Oven Drying

This is a faster method of drying biomass briquettes that involves using an oven or a kiln (Figure 2.10). The briquettes are placed in a heated chamber where hot air is circulated around them, and they are dried at a temperature of around 70-80 °C for about 1 hour until they are completely dry. This method is faster but requires more energy and is expensive.

Figure 2.10: Oven drying machine

Summary

Overall, the method used for drying biomass briquettes will depend on the availability of resources, the quantity of briquettes, and the required speed and quality of drying. It's important to choose a method that will ensure the briquettes are completely dry (moisture content ≤ 10%) and stable, to prevent them from deteriorating and losing their effectiveness as a fuel source.

2.6 Quality Test

The produced biomass briquettes must be analyzed to determine the basic quality parameters (physical and chemical properties) using standard methods at a recognized laboratory.

2.7 Packaging and Labeling

There are several important factors to consider in packaging and labeling of biomass briquette containers and bags. Here are some guidelines to follow.

2.7.1 Packaging Material

The packaging material should be durable and able to withstand the weight of the briquettes. Common packaging materials include cardboard boxes, plastic bags (recyclable materials), paper bags, jute bags, and wooden crates (Figure 2.11). It should be noted that plastic packaging material are air tight.

a. Packaging Size

The size of the packaging should be appropriate for the quantity of briquettes. The packaging should not be too big as it may cause

the briquettes to shift during transportation, and not too small as it may not be able to hold the briquettes securely.

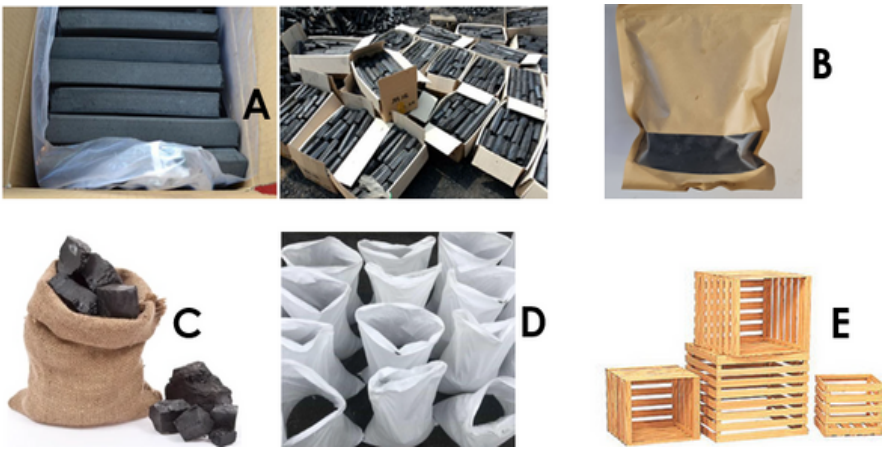

Figure 2.11: Examples of packaging materials such as Cardboard boxes (A), Paper bag (B), jute bags (C), Plastic bags (D) and Wooden crates (E).

2.7.2 Labeling Information

The label should clearly indicate the type of biomass material used, the weight, and the manufacturer's name and address. The label should also include instructions for use, storage, shipping regulations and any safety precautions that should be taken when handling the briquettes. If the briquettes are to be exported to other countries, then it is important to enquire about the specific country's labelling requirements.

For example, some countries require the label to include information about the carbon emissions savings compared to

traditional fuels. If this is a requirement in order to export the product out of Tanzania, then manufacturer should comply.

Summary

Proper packaging and labeling are important for ensuring the safe and effective transportation of briquettes. It also provides aesthetic value to the product for users and market. Effective following of these guidelines, briquette producers ensures that their products are properly identified, handled, stored, and that customers have the right information they need to use the briquettes safely and effectively.

2.8 Storage of Dried Briquettes

Dried biomass briquettes should be stored in a cool and dry place to prevent moisture absorption, which leads to degradation and mold growth. Ideally, the temperature should be between 10-25°C and the relative humidity should be less than 50%. Some additional tips to select a right storage location for briquettes:

a. Choose a dry location. Avoid storing your briquettes in a damp or humid environment,

b. Keep the location cool. High temperatures (above 50 °C) also cause the briquettes to degrade, so it is important to store them in a cool environment.

c. Avoid direct sunlight. Exposure to direct sunlight causes the briquettes to dry out and become brittle. It is best to store them in a shaded area or in a container that does not allow sunlight penetration,

d. **Check the storage location regularly.** It is important to check the storage location regularly for any signs of moisture or mold growth. If any issues are found, take steps to address them immediately,

e. **Consider using a dehumidifier.** If you live in a humid climate, use a dehumidifier in the storage location to help keep the environment dry.

SECTION 3

3 Basic Machines and Equipment for Making Biomass Briquettes

Briquetting of biomass is done either by hand, by hand with help of machines or all by machines only. Following general briquetting process, the machines/equipment that can be utilized in the process are as follows.

3.1 Sieving/Screening Machine

This is an equipment used to sort unwanted materials from desired ones and make different particle sizes of the material. It can be handmade or industrially manufactured. Its size depends on the user requirements and its operational handling mechanism. Handling mechanism may be by hand and by one person or two people, manually operated or automated. Sieving may be required during raw material preparation and after grinding, milling, and shredding (Figure 3.1).

Figure 3.1: Sieving/screening tools

3.1.1 Dryer

Depending on the location, weather and scale of biomass briquetting, the following are some of the options for drying biomass materials and briquettes during briquetting process: direct sun drying, open air drying, solar drying, hybrid drying, and hot air drying. Also, these options determine the type of machine to use.

a. Racks or mats

These kinds of equipment are used to dry materials and briquettes using the direct Sun and open air. These are the most applied dryers even though they are weather and season dependent. They can easily be made with locally available materials like wood, wire-mesh, and nails (Figure 3.2). They can be managed by one or more people.

Figure 3.2. The sun/open air-drying facilities for biomass briquettes

b. Solar dryers

These are usually made up of enclosed spaces with racks and trays to hold materials for drying. Solar uses special plastic to trap energy from the sun and retain it to create a greenhouse effect creating temperature difference between enclosed space and outside

environment. Moisture is driven out and escapes through vents or windows of the structure (Figure 3.3).

Figure 3.3. The solar drying unit

c. Hybrid dryers

These are supplied with more than one source of energy alternatively. For example, biogas can supplement solar energy when there is no sunlight (Figure 3.4).

Figure 3.4: Solar-Biomass hybrid drying system machine with carbonized coconut shells crushed

d. Hot air dryer

This is the most common dryer as of today whereby the required heat to dry the material is carried by a hot air. The hot air passes

through the material and briquettes and exits from the drier continuously during the drying stage as Figure 3.5 shows.

Figure 3.5 : Hot air dryers

3.1.2 Grinder/miller/shredder

Hammer mills (Figure 3.6), jaw crushers, pulverizers, and shredders reduce size of materials. As their names suggest, they are used during grinding, milling, and shredding stages. These machines can be handmade or industrially produced. Operational capacity depends on the material being processed and the amount of output desired. The machines can be handled manually by one or more people and automatically.

Figure 3.6: Milling/crusher machine with carbonized coconut shells crushed

3.1.3 Carbonizer

This is an equipment used to make biochar from raw biomass materials under controlled conditions. Usually, the material is heated in a limited supply of oxygen and at a specified temperature (350-450°C). The machines can also be manufactured by-hand and industrially and can be managed manually by one person and automatically (Figure 3.7).

Figure 3.7: Different types of Carbonizer machines

3.1.4 Mixer

This machine is used to uniformly mix the raw materials such as binder and biomass (biochar)before compaction into briquettes. There are different types of mixers. Typical examples include wheel mixer and horizontal drums (Figure 3.8).

Figure 3.8: Mixing machine - wheel mixer (left) and horizontal mixer (right)

3.1.5 Briquetting Machine

This is the machine used to form biomass briquettes of different shapes depending on its type as shown in Figure 3.9. The types are screw extruder, piston press, roller press, hydraulic press.

The equipment is manufactured manually and industrially and can be managed manually by one or more people and automatically. These machines are used during compaction stage. Forming of briquettes can also be done by hand; however, their physical integration may be weak.

Figure 3.9: Biomass briquette machine including piston press (A), Hydraulic press (B), Roller press (C) and Screw extruder.

3.1.6 Cookstoves, Cooking Utensils, and Stirrers

These pieces of equipment are also used in the production of biomass briquettes. They are used to prepare raw materials such as starch and gum to create binder that need to be gelatinized. They are manufactured by hand and industrially. They can be managed manually or automatically.

3.2 Biomass Briquettes Production Area and Working Environment

Factors for setting up briquettes production facility varies depending on the scale of production, technology, machinery used, and quality of biomass briquettes to be produced. Other factors are environmental regulations in place, and whether the production takes place in residential, industrial dedicated areas, urban and sub-urban areas.

For all settings, one has to keep in mind that there are constant requirements. Sufficient space for storage and drying raw materials and briquettes and production of biomass briquettes should be taken into consideration (Figure 3.10).

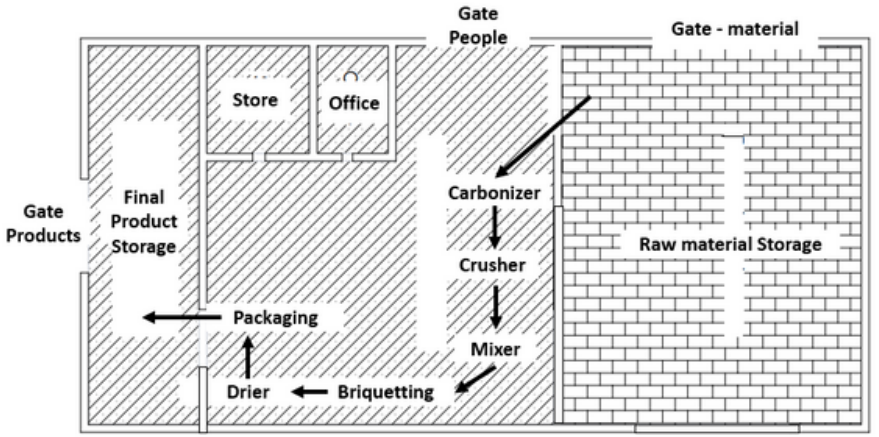

Figure 3.10: Factory Layout for biomass briquette production

The process involves waste production, especially dust and noise, so ways of reducing such wastes should be kept in mind before setting up the production facility. These include spreading some water over whole carbonized material before crushing or milling and proper tightening of the milling/crushing machine. Most of the

time the process involves use of machines powered by electricity, especially for compaction or densification stage. Therefore, access to reliable sources of power either electric or fossil fuel, e.g., diesel powered is an important factor when setting up the production site.

SECTION 4

4 SUSTAINABILITY ASPECT

The sustainability of biomass briquettes depends on market size and share, availability of potential plants and sources of binder materials.

4.1 Biomass Briquettes Market Size and Share

The estimated use and demand for biomass energy in Tanzania is close to 90% according to a study conducted in year 2018.

4.1.1 Sustainable Supply of Raw Materials

Sustainability is a critical factor to consider when sourcing biomass raw materials for briquetting. It is essential to ensure that the biomass is sourced in a way that it does not have a short and long-term negative impact on the environment. Some of the key sustainability considerations include:

a. Land Use

It is essential to ensure that biomass is sourced from land that is not being used for food production or for other critical purposes such as conservation or cultural practices. The land should also be used in a way that does not degrade the soil or cause erosion, which can lead to long-term land degradation.

b. Biodiversity

The sourcing of biomass should not have a negative impact on the biodiversity of the area. This means, the harvesting of biomass should be done in a way that does not damage the habitat of wildlife or the ecosystem.

c. Greenhouse gas emissions

The sourcing and transportation of biomass should be done in a way that does not result in excessive greenhouse gas emissions. This can be achieved by using sustainable transportation methods such as trains or ships instead of trucks. Sourcing biomass from local areas will cut down on the transport cost and minimize resulting greenhouse gas emissions.

d. Renewable resources

It is important to ensure that the biomass raw materials are sourced from renewable resources that can be replenished over time. This helps to ensure the long-term sustainability of the biomass industry and reduce reliance on finite resources.

e. Social sustainability

The sourcing of biomass should also consider social sustainability factors such as fair labor practices and community engagement. This includes ensuring that the people involved in the sourcing and transportation of biomass are paid fair wages and local communities are involved in decision-making processes.

Overall, sustainable sourcing of biomass raw materials for briquetting involves considering the environmental, social, and economic impacts of the sourcing and transportation of biomass. By taking a holistic approach, it is possible to establish a sustainable and reliable supply of biomass raw materials for the biomass industry.

4.2 Potential Plants for Biomass Briquetting

These plants and plant residues can be used as feedstock for biomass briquetting. They have varying properties such as moisture content, ash content, and calorific value, that make them suitable for different applications. Table 4.1 shows a list of some potential plants that can be used as raw materials for biomass briquettes.

Table 4.1: Potential plants for biomass briquettes raw material

Sn	Plant name	Calorific Value MJ/kg	Ash content %	Moisture content %
1	Switchgrass	18-20	Less than 5	15-20
2	Miscanthus	18-21	Less than 5	10-15
3	Willow	16-18	Less than 5	30-50
4	Hemp	16-19	Less than 5	10-15
5	Silax	18-20	Less than 4	20-30
6	Jatropha	18-22	Less than 5	5-8
7	Moringa	18-19	Less than 5	10-20
8	Giant reed	17-19	Less than 5	10-20
9	Sida	17-19	Less than 5	10-20
10	Eucalyptus	17-19	Less than 5	20-30

Source: Parra et al., 2023

4.3 Potential Sources for Sustainable Binder Materials

There are several non-food plants that can be used to generate binder materials for biomass briquetting. Here is a list of a few examples:

a. Jatropha: This is a tropical plant that is grown for its oil-rich seeds. The oil can be used as a binder material in biomass briquetting,

b. Castor: It is a plant that is grown for its oil-rich seeds. The oil can be used as a binder material in biomass briquetting. In addition, the binder material can also be extracted from the seed cake that is left over after the oil has been milled. However, one of the disadvantages of using castor is that the plant is toxic to humans and animals if ingested. This means that care must be taken during the milling process to ensure that the binder material is free from toxic compounds,

c. Tapioca: Tapioca is a root vegetable that is grown primarily in the tropical regions. It is a good source of starch, which can be extracted and used as a binder material in biomass briquetting,

d. Cassava peels: Cassava is another root vegetable that is grown primarily in the tropical regions. Like tapioca, it is a good source of starch, which can be used as a binder material in biomass briquetting,

e. Lignin-rich plants: Lignin is a complex organic polymer that is found in the cell walls of many plants. Plants that are rich in lignin such as switchgrass and miscanthus can be used to generate binder materials for biomass briquetting,

f. Tree bark: The bark of certain trees such as the acacia tree are used as a natural binder material in biomass briquetting.

In overall, there are many different non-food plants that are used to generate binder materials for biomass briquetting. The choice of

plant depends on factors such as the availability of the plant in a given region, the desired properties of the binder material, and the cost of production.

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Biomass Briquettes production handbook provides steps to follow to Produce quality carbonized biomass briquettes. The handbook contains all the improtant information required by small or medium scale biomass biquette producer for production of biomss briquetts that meet the national standard.

The biomass briquettes handbook reveals:

- Important materials and basic machines required for production of carbonized biomass briquttes.
- Steps to follow from materials preparation to packing of final product.
- Potential biomass materials and binder which can be utilized for sustainability of biomss briquettes industry.

Tanzania Indusrtial Research and Development Organization (TIRDO) through her Environment and Energy Divions offers different services on renewable energy including but not limited to; quality tests of fuel, testing of cookstove effeciency, fuel and stove emission tests, training related to production of renewable and clean energy. It also provides technical support regarding establishment of renewable energy plants/industries and energy audit in industrial utilities and commercial buildings.

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